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IUFRO/MAB Conference: Research on Multiple Use of Forest Resources

May 18-23, 1980
Flagstaff, Arizona

IUFRO

INTERNATIONAL UNION OF FORESTRY RESEARCH ORGANIZATIONS

MaB

UNESCO PROGRAM ON MAN AND THE BIOSPHERE

CONFERENCE EXECUTIVE COMMITTEE

IUFRO/MAB Conference: Research on Multiple Use of Forest Resources

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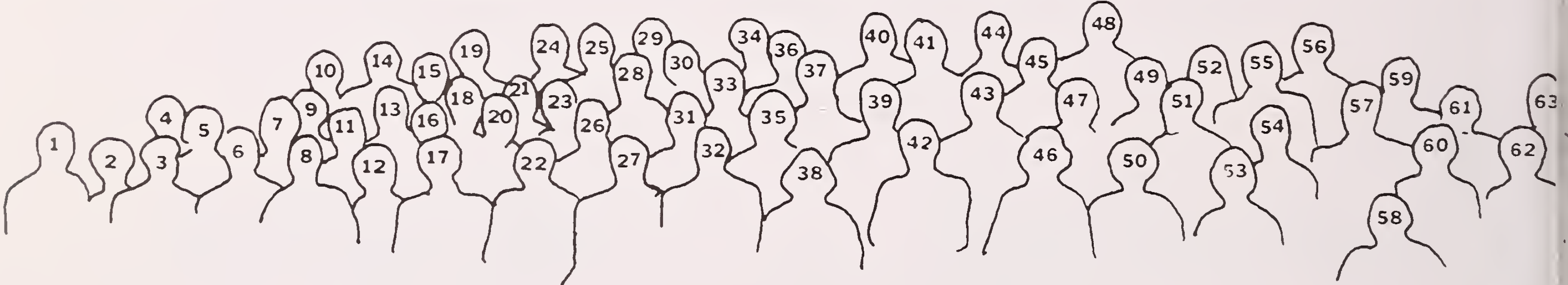
Participants of the IUFRO/MAB Conference, Flagstaff, Arizona



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Introduction to the Conference

Warren T. Doolittle[1], Chairman
IUFRO Working Party on Multiple-Use Silviculture

As overall chairman of this conference, it gives me great pleasure to welcome you. I appreciate your coming here from all over the world to participate in this meeting.

Before I introduce the keynote speaker, I would like to speak to you briefly about the background and purpose of this conference, a few words about what is ahead of us this week, and recognize the people who planned and are carrying out this conference.

This conference is being sponsored jointly by the International Union of Forestry Research Organizations (IUFRO) and the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Man and the Biosphere (MAB) Program. More specifically, the conference comes under the IUFRO Working Party on Multiple Use Silviculture, of which I am chairman, and the MAB Directorate on Temperate and Mediterranean Forests, of which Dr. Peter Ffolliott of the University of Arizona is chairman.

Also cooperating with us here at this meeting is the IUFRO Working Party on Natural Parks, National Parks, and Wilderness, chaired by Dr. Carl Berntsen of the Society of American Foresters. This is a new working party which Dr. Berntsen is just getting organized.

We should recognize that three organizations here on the ground in Arizona really are putting on this conference for MAB and IUFRO. These are the University of Arizona, Northern Arizona University, and the Rocky Mountain Forest and Range Experiment Station of the U.S. Department of Agriculture's Forest Service.

I am sure all of you know that both MAB and IUFRO are international research organizations. IUFRO was founded in 1890 to rationalize research techniques, standardize systems of measurement, and promote international cooperation in forestry research. It has a membership of 10,000 scientists from 89 countries. MAB was founded by UNESCO in in 1970. It provides an integrated interdisciplinary approach to applied research problems arising from the impacts of man on natural resources and the environment. Major concerns of MAB are tropical, temperate zone, and Mediterranean forests, and Biosphere Reserves. MAB has membership in over 90 countries. So it is only natural that these two organizations have joined forces here this week to focus on multiple-use research on forest resources.

The purpose of the conference, in brief, is to bring together international research experiences on the multiple use of forest resources -- to explore and share these experiences. The focus is on research, but includes four aspects of multiple-use research: techniques of research, status and progress of research, application of research, and costs/benefits of practicing multiple use. These aspects of multiple-use research will be covered by papers presented here, by field trips, the post-conference tour, and through informal exchanges of information between participants during the week.

Flagstaff was chosen for the site of this conference mainly because of the location of the Beaver Creek Experimental Forest in the Coconino National Forest near here. Beaver Creek has long been a major experimental area for the Forest Service. Over the years, some of the best multiple-use research in the United States has been conducted here by the Forest Service and university cooperators. We will spend Wednesday visiting Beaver Creek, hearing about and seeing multiple-use research. Those of you who were here yesterday afternoon at the dedication also know that Beaver Creek is a Biosphere Reserve under the MAB program, and is linked cooperatively to the La Michilia Biosphere Reserve in Mexico.

We will be visiting Grand Canyon National Park on Thursday, with many points of interest enroute. And the post-conference tour Saturday and Sunday will take you through several forest and desert types.

On Thursday evening, our banquet speaker will relate the history and development of multiple use in the management of National Forests in the United States. His presentation, the only one at this conference that does not deal with some aspect of research, should be a good backdrop to our research endeavors here this week.

So often at affairs like this, little credit is given to the people who plan and run the conference. Today I would like to move this recognition to the front of the conference. Members of the conference Executive Committee were: Program Chairmen Drs. Krebill and Zube; Meeting Chairmen Drs. Ffolliott and Patton; Arrangements Chairmen Drs. Ronco and Minor; Spouses Program Mrs. Kent and Ronco; and Editor of the Proceedings, Mr. Hamre. I would also like to give special recognition to Mrs. Phylis Rubin and Mr. Jay Blowers of the Office of the Secretariat of the U.S. Man and the Biosphere Program in Washington, D.C.

A special thanks is due also to the speakers, who prepared their papers in camera-ready form to speed publication of the proceedings. It took a lot of work on their part, so I hope you will overlook a few inevitable typographical errors and minor differences in format. Have a good conference!

[1] Associate Deputy Chief for Research, Forest Service, U.S. Department of Agriculture, Washington, D.C.

Introduction to the First Day

Arturo Gomez-Pompa, Day Chairman
Director General, Department of Biotic Resources
Xalapa, Mexico

Before we begin our sessions, I will take a few minutes to share with you some thoughts about the importance of this meeting in relation to the problem of man's actions on the biosphere.

Millions of hectares are deforested every year in the world. We know that since man appeared on earth this action has been going on. Through the times this action has damaged his environment, and we know through history of the declining of important centers of civilization following these actions.

Today we are witnesses to the most important acts of deforestation, especially in tropical areas, in the history of man. With this comes the destruction of germplasm containing options for the future, loss of soils, and loss of fixed carbon dioxide, with all the unknown consequences. This frightening path parallels other actions of man which are no less frightening: the massive use of pesticides, and the contamination, of all kinds, of air, water, and soil. The explosive increase in population and mismanagement of fossil energy etc. have had such an impact on the biosphere that they have led to the organization of international programs such as the MAB program in an effort to find solutions to the dangerous problems facing humankind today.

It is in this context that this meeting has its real value. Scientists from many different countries are gathered here to contribute their experience and knowledge to the multiple use of forests. This subject has been selected by MAB of UNESCO as a possible answer to the deforestation process of the world. It has been recognized that deforestation, especially in the tropical areas, has been caused by three factors:

1. Tropical forests are mixed and mostly composed of unknown species of trees; technology to manage these forests properly is lacking.
2. The need to produce food is followed by the opening of new agricultural soils, most of which are forest soils.
3. The demand for meat in the world market has promoted the conversion of tropical forests to pasture lands.

For these reasons, it seems of foremost importance to find ways to use the forests properly and to look for compatible actions to produce food for man and cattle from them; or to find schemes in which forests, agriculture, and pasture could be complementary activities and not alternatives for the use of forest areas.

I feel that meetings such as this and the wisdom of humankind can help us find the right path in the future. For this, we will need open and enthusiastic international cooperation to learn from each other about our common problems, and from these to look for the proper solutions for each country according to its own political, social, and economic organization and needs.

Keynote Address:

Multiple-Use Research[1]

K. F. S. King[2]

The forests of the world are under attack in both the developing and the developed worlds. In the developing countries they are being felled to provide some of the basic necessities of life. In the developed countries their management is being curtailed and restricted because of the demands of the affluent for areas of recreation. Multiple-use forests might be a solution to both sets of problems. Multiple-use forest management must, however, be under-pinned by research. Unfortunately, in most areas of multiple use the basic data needed for planning and decisionmaking are not readily available. Moreover, in some cases, certain combinations of use appear to be incompatible. There is therefore a very basic need for research, both to provide the necessary information for planning and decisionmaking, and also for reconciling the apparently conflicting requirements of the individual components of some multi-purpose combinations. Specific fields of research are suggested. Special attention is paid to agroforestry systems, which not only produce food and wood, but also conserve the ecosystem. Agroforestry seems to be one of the answers to the problem of tropical deforestation.

INTRODUCTION

The forests of the world are under attack everywhere. In the developing countries, mankind in his desperate fight to provide the basic necessities of food and shelter clears forests to free land of trees so that he might produce agricultural crops for his very sustenance. He rapes the forests to provide fuel for warmth and cooking. He ravages the forests for poles to assist him in the erection of shelter to protect himself and family from the elements. He exploits the forests to provide raw material for industries to earn foreign exchange, and to create employment opportunities.

In many cases, indeed in most instances, the pursuit of these objectives is laudable and essential. Yet in their effort just to stay alive, the forest dweller and peasant and the officials of the developing world frequently ignore the fragile nature of tropical forest ecosystems. They frequently fail to appreciate the pervasive influence of the services which the forests provide. They frequently attempt to assess the results of tropical deforestation: the erosion which leads to the siltation of rivers, to floods and to droughts; to the sedimentation of reservoirs and the failure of hydroelectric schemes to perform efficiently; to the destruction of crops produced on land that is inherently incapable of sustaining agriculture; to the creation of impure and polluted water supplies, especially in rural areas where the absence of appropriate social and physicial infrastructure for purification inevitably leads to disease and early deaths; in short to the aggravation of human misery which seems to be the lot of most of the people of the developing world; indeed, of a sizeable proportion of the population of the entire planet.

The United Nations Environmental Programme has forecast that, in Central and South America, the natural tropical forests will shrink from 788 million hectares in 1975 to 562 million by the year 2000; that in Africa south of the Sahara, the natural tropical hardwood forests will be reduced from 202 million hectares in 1975 to 187 million hectares in 2000; and that in Asia and the Far East closed natural forests will diminish in area from 291 million hectares in 1975 to 243 million hectares in the year 2000 (UNEP, 1980).

It should be noted that these figures "refer only to forest cover that is entirely removed once and for all, to be replaced by non-forest types of vegetation. They do not consider anything in between, e.g. disruption and degradation of forest ecosystems". The situation with respect to the pressure on tropical forests is therefore alarming, and if permitted to continue could result in untold damage to the ecosystems of the developing world, to their future productivity, to their rates of economic growth, and to their general development.

The situation with respect to the pressure on the forests of the developed countries is a little

[1] Keynote address at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18 - 23, 1980, Flagstaff, Arizona.

[2] Director General of the International Council for Research and Agroforestry, Nairobi, Kenya.

different. In the developed countries, it is not the categorical imperatives of hunger and want that result in the dimunition of the size of the productive forests. On the contrary, it is the imperative of affluence which threatens to disturb, indeed which is already destroying, the traditional methods of forest management.

The continued rise in the standard of living in the developed world since the end of the last World War, has led to new demands on the natural resources of these countries. In the developed world there are demands, which are often being translated into law, that large areas of forests be made inviolate and inviolable; not to be managed in any form or manner; be set aside for recreation and amenity values.

In the developed countries, rising standards of living, imporved mobility, the pressures of the industrial society, the desire of modern industrial man to escape from the often debilitating spiritual and psychological effects of the very society which provides him with material benefits, have led to the forests being perceived not only as producers of wood for industry, but also as havens to which modern man might retreat to re-create himself, to commune with nature, some might say to escape from himself. Whatever the reason, the productive forest is shrinking--shrinking at a time when the demand for wood and wood products is rising and, if the forecasts of future demand by the Food and Agriculture Organization of the United Nations are to be believed, will continue to grow in the years ahead.

We have, therefore, what might appear to some to be a paradoxical situation: in both the developed and developing countries, because of the processes of development, and in spite of the growing demands for wood and wood products, there is a shrinking of the productive forest area.

If this analysis is valid, some means must be found for providing the multiplicity of goods and services the forests are capable of yielding. In other words, there must be "multiple use" of the forest resources of the world.

WHAT IS MULTIPLE USE?

Multiple use has been defined as the conscious and deliberate use of the land for the concurrent production of more than one good or service (Gregory, 1955). I should like to direct your attention to the phrase "conscious and deliberate". Multiple use is the conscious and deliberate use of forests.

Forests, by their very existence, because of their physiognomy, because of the physiological processes which occur in them, and because of the nature of their soils, provide a protective cover to the earth's surface, minimize erosion, reduce the incidence of floods and droughts, regulate the supply of water and purify the water supply. The forests perform these functions naturally, if left undisturbed, or if not disturbed to such an extent that their protective function is adversely affected.

Forests, by their very presence, are considered by many to be places of recreation.

Forests, by their very presence, harbor various forms of wildlife.

Forests, by their very presence, provide herbaceous and shrubby vegetation which can be grazed and browsed, and which can be used as fodder for domestic livestock.

The point I want to make is that although these multiple services, these multiple benefits are provided by most forests, I do not consider this to be multiple use. Multiple use must be conscious and deliberate. What I hope we will consider today, and in the ensuing days, is the research effort needed to provide the basic information necessary to manage the forests for the concurrent production of more then one good or service. What I hope also that we will examine during this week, are the research results which have already been obtained with respect to the production of these individual goods and services which the forests yield, and that are relevant to multiple-use management. I hope we will also discuss in the coming days the synthesis of the knowledge we possess of individual goods and services, and the means we might adopt in applying this knowledge to the forest when viewed as a system that can be managed and manipulated to produce a combination of goods and/or services.

The Fifth World Forestry Congress, which was held in this country in 1960, chose as its theme "the multiple use of forests". At that Congress it was stated that the main uses to which forests might be put were the production of timber, the regulation and purification of water supplies, the provision of range facilities, the provision of wildlife, and the provision of recreational facilities. I would like to suggest that this list of uses is far from exhaustive, and that to it might be added the use of forest land for the concurrent production of food, fodder, and tree crops; the utilization of the forests not only for timber, poles, and fuel but also for food and feed; and the utilization of the forests for chemicals, pharmaceuticals, medicines, etc. I would like to suggest further, that the categories of forest-use, and therefore of multiple use, are not closed; that there should be continuous research with the objective of discovering new types of wood products and new means of utilizing the forest ecosystem.

The perceptive among you will have noticed that I consider the possible number of combinations of known uses of the forests to be extremely high, and the possible numbers of potential uses of the forests to be almost infinite. It is evident, therefore, that I cannot examine the gamut of multiple-use combinations in an address such as this. I therefore propose to limit myself to those combinations that seem to me to be most relevant, or most pressing in our times, and to identifying as far as

possible the research necessary to underpin these combinations and to provide a factual base for multiple-use management.

Within this context I propose briefly to describe the problems and research needs in:

a. the regulation of water supplies and the production of timber;
b. the management of forests for both wildlife and timber production;
c. the protection of the soil and the production of timber;
d. the use of the forests for the combined provision of recreational facilities and the production of timber; and
e. the production of agricultural (include forage) and forests crops from the same unit of land.

However, before disucssing these combinations, I wish to make a few general points. First, although I have chosen to discuss combinations which embrace only two goods and/or services, it is possible, of course, to manage forests for a combination of more than two goods and services. Second, the production of each of the individual goods and services that are part of the multiple-use package cannot be maximized. What can be maximized is the combined production of the various goods and services. Third, often there has to be a dominant use in the "utilization mix". It is possible to envisage a system in which equal weight is given to two or more objectives of management in multiple-use land utilization systems, but the attainment of such goals is difficult.

These points are, to me, self-evident. I wish merely to refresh your memory of them.

The fourth and fifth points, however, may perhaps deserve more of your attention. The fourth point is that, in order to build up a system of land management designed to produce more than one good or service from the same unit of land, the mechanics of single-use systems must be thoroughly understood. For example, within the context of managing forest land solely for the purpose of regulating water supplies, we should know what species, or combination of species, are best suited for the objective; what stocking densities are optimal at the various stages of growth of the forest crop and at maturity; what frequency of cutting should be undertaken to regulate water supply, and so on.

Again in order to maximize the production of timber on a given site, we should be aware of the best species to be planted, the best genotypes, the management practices to be followed, the rates of regeneration of the selected species, and so on.

These are only a few examples of the basic knowledge required in two of the most often practised systems in single-use forestry. And yet our knowledge of these necessary factors in simple, single-use forestry is generally lacking both in the developed and developing economies.

In multiple-use forestry we increase the number of variables by introducing more than one objective, and as a consequence, the complexity of management and of research is considerably increased. Multiple-use research must therefore be based in part on sound single-use research, and that has to be improved considerably throughout the world.

The fifth and last point follows logically, I believe, from the definition of multiple-use I gave earlier: "the conscious and deliberate use of land for the concurrent production of more than one good or service". We should therefore be able to predict the expected outputs from the system, given certain sites and inputs; we should be able to manipulate the inputs in order to attain required outputs; we should be able to quantify the costs and benefits of various aspects of the system. We should be able, in other words, to progress from the subjective assessments that alas seem to be the only course open to the forest manager, (because the research data are simply not available) to the quantitative, factual and objective assessments that are the hall-mark of the respectable scientist.

Now let us return to the discussion of what I described as "combinations that seem to me to be the most relevant to, and to be the most pressing of our times".

THE REGULATION OF WATER SUPPLIES AND PRODUCTION OF TIMBER

Among the earth sciences, hydrology is far behind the others in the evaluation of a set of first principles (Penman, 1962). Too much of the textbook material is expressed in statistical relations unsupported by scientific reasons, and the conclusions drawn from the relations are frequently no more than opinions. These opinions are usually quite sound in their own context, but some of the attempts to extrapolate them to other environments have failed because elementary principles in meterology, plant growth, or soil science were unknown or ignored. Perhaps because of these failures, there is a strong attitude of despair towards catchment hydrology, expressed in the belief that every catchment is unique and its problems must be solved on the spot, without importation of experience from outside, and with no hope of being able to export any newly acquired experience.

This is, of course, a generalization. Never-the-less the belief expressed is sufficiently widely held for me to be of the opinion that this Conference should devote some time to considering whether effort should not be made either through the Man and the Biosphere Programme, or through the International Union of Forestry Research Organizations, or both, to develop and publish a "set of first principles". It is hoped that this will also emphasize that the behavior of a catchment must be considered as a single problem, the conventional components of which have interactions that are often more important than their individual characters. There is need also for a compilation of existing information that is exptrapolable.

There is also need for an identification of those forest species which will not only grow well on particular catchments, but the physiology of which make them particularly suitable for the regulation of water supplies. Factors which ought to be taken into consideration are, for example, their rooting habit, their rate of uptake of water from the soil, their rates of evapo-transpiration, their phenology, and the influence of this on water loss and uptake. In addition, the management systems that are best suited to desired water regimes should be studied.

At the risk of repetition, I should like to stress that what I am pleading for is a more systematic approach to forest hydrology research, a recognition of the catchment as a system, an incorporation of forest management practices into this system, and a synthesis and publication of extrapolable results.

COMBINATION OF WILDLIFE MANAGEMENT WITH TIMBER PRODUCTION

There are fundamental problems in this type of multiple use which still remain to be solved, and which often cause conflict between the forest manager and the wildlife specialist. Indeed, there is a school of thought which strongly expresses the opinion that the production of timber and the management of wildlife are incompatible.

The problems center around the damage that is undoubtedly caused by wild animals to the forest crop at all stages of the latter's development: seedlings are eaten and trampled making both natural and artificial regeneration difficult,and in some cases impossible; the leading shoots are broken or eaten at the pole stage, thereby reducing the value of the young forest crop and making it more prone to insect and fungal attack; tree bark is abraded, torn and eaten in the more mature stage, thus again increasing the trees' and the forests' susceptibility to diseases.

These misgivings on the compatability of wildlife and forests are real and the allegation of damage caused by wildlife are well documented. Yet the advantages which accrue to a nation because of its possession of wildlife, through tourism which earns it foreign exchange and creates employment, through the provision of portein for some of its population, and through the conservation of its faunal gene pool are equally compelling. Research should therefore be directed towards the solution of these problems of apparent incompatibility, and towards reducing and eventually minimizing the damage caused by forests by wildlife. The choice of species for planation establishment in wildlife areas should be given more attention; economic, mechanical means of protecting inmature forests from the depredation of wild animals should be researched on a wider, but more intensive scale; the evoluation, both in natural and artificial forests, of silvicultural practices designed to ensure that the tree crop passes through its most vulnerable stage of growth in as short a time as possible should be concentrated upon. And, perhaps, research might be undertaken with respect to the provision of suitable feed for wild animals in those forest areas that are no longer as susceptible to wildlife damage as the younger forests.

My impression is that much of the research being undertaken by wildlife specialists largely ignores the fundamental question of forest damage. It is also my opinion that the research being undertaken by forest scientists who work in areas that are heavily populated by wildlife is not being directed to this fundamental problem of multiple use--the compatibility of forest and wildlife species.

THE PROTECTION OF SOIL AND PRODUCTION OF TIMBER

The strictures I leveled against the science of hydrology apply, although to a lesser extent, to the conservation of soil and the production of timber. It is true that, through the work of researchers in national organizations, for example here in the United States and in India, a body of basic principles in soil conservation is being built up. It is true that the Food and Agriculture Organization of the United Nations has published a series of documents which draw upon the knowledge accumulated in various parts of the world, and which attempt to establish principles of universal applicability. It seems to me, however, that we have not delved deeply enough into the effects of the interaction of specific species of trees and sites on soil conservation and reclamation; that we have little or no information which would enable us to predict with any certainty the quantity of erosion that would occur if forests were exploited at various intensities either in the developed or in the developing world; that we do not know how to manage and how to manipulate our forests in order to achieve a desired quantity of timber production and to attain a desired degree of erosion control.

I have a suspicion that some of you might question these last statements, and point to this or that piece of research which has demonstrated that when forests are removed or are severely exploited there is accelerated erosion. I do not quarrel with this. Indeed, I myself have often preached the gospel of forest conservation, precisely because I am aware of the overwhelming mass of evidence which supports the contention that the removal of forests leads to erosion.

However, my case is that the evidence is often obtained after the event; that we have not yet built up our research experience to such an extent that we are able to predict to the planner and the forest and land manager what would happen to the soil resource if this or that forest were exploited to this or that intensity.

The consequence is that a group of alarmists bestride the world, predicting catastrophe if the world's forests are exploited for essential timber production, for timber which would provide jobs for

starving people, which would provide foreign exchange for the development of the poverty-stricken of the world.

And yet, the tools exist. It is possible to construct simulation models which would provide data on which forest management prodictions might be based, data which would enable us to exploit the forest rationally and yet conserve the soil and other factors of the ecosystem. Work in this area should be intensified if we are to remove the hysteria and emotion from forest management. I cannot stress this too strongly. The forest policy maker and management specialist needs information which would enable him to foresee with a reasonable degree of certainty what would happen to the ecosystem if certain management practices were followed. We must utilize all the available modern reserach techniques and methodologies to enable him to obtain this information.

COMBINING FOREST RECREATION AND TIMBER PRODUCTION

It appears to me that the research which ought to be concluded to reconcile the often conflicting demands of the protagonists of forest recreation and those of the forest producer, which is my next subject, is basically socio-economic. This research effort should be directed, indeed it is already being directed towards ascertaining the attitudes of the public toward various types of forest management: exploitation, thinning, road construction, and so on. The problems have, to a large extent, been recognized and identified. What remains to be done is a refining of the methodology designed to quantify the various attitudes, and the formulation of research instruments and techniques that would enable the planner and land manager to relate the attitudinal findings to the management of the forest for timber production. It appears to me that an acceptable methodology in this regard has not yet been evolved. And the problem is compounded by the fact that there are several types of tourist who demand different recreational services from the forests (Vaux, 1960). Some ride through the forest and desire to see only aesthetic surroundings as they pass through; others actually stop and enter the forests; and others seek remoteness and wilderness conditions.

I have stated that the research problems attendant on the management of forests for recreation production purposes are basically socio-economic. However, if, as is often the case, large areas are set aside from exploitation so as not to disturb the aesthetic senses of the visitor, it is evident that if production levels are to be maintained, certain silvicultural practices will have to be adopted to increase productivity in the reduced production area. Thus, research in these cases ought also to be conducted in choosing fast-growing species and varieties, in reducing forest rotations, and indeed in maximizing yields in the restricted areas.

THE PRODUCTION OF AGRICULTURAL AND FOREST CROPS FROM THE SAME UNIT OF LAND

Earlier, I touched briefly on the problems of tropical deforestation, and pointed out that, although we cannot predict with any certainty, in quantitative terms, the effect of deforestation on tropical ecosystems and on the economies of developing countries, it was evident that tropical deforestation imposed severe stresses on ecosystems, and adversely influenced the welfare of mankind.

But the problem is not simply one of arresting tropical forest degradation, or of restoring forest cover on areas in which they are most required. Most governments would do so if they could afford it. And most tropical farmers would desist from felling tropical forests, from shifting from area to area each year or two, from seeing the yields of their food crops drop as soil fertility diminishes, from suffering from periodic floods and droughts, if they were offered viable alternatives.

We must therefore attempt to evolve a system which would reduce the costs of forest plantation establishment, which would ensure that the protective cover of forests in the tropics is maintained and/or restored, and which would, at the same time, permit forest land to be utilized for the production of food and/or the rearing of animals. In short, a system which produces as it conserves. Such a system is agroforestry.

Definitions

Agroforestry has been defined as "a sustainable land management system which increases the yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land, and applies management practices that are compatible with the cultural practices of the local population" (Bene et al 1977; King and Chandler, 1978).

An attempt has been made elsewhere (King, 1978) to expand the definition, and to distinguish various sub-divisions of agroforestry.

Agroforestry is a generic term which embraces the following components.

Agri-silviculture - the conscious and deliberate use of land for the concurrent production of agricultural crops (including tree crops) and forest crops.

Sylvopastural systems - land management systems in which forests are managed for the production of wood as well as for the rearing of domesticated animals. It should be noted that in this system the animals are kept and permitted to graxe within the forests. Sylvopastoral systems should therefore be distinguished from systems in which forage (either herbaceous or shrubby) is grown in mixture with forest trees. These latter systems are properly agri-silvicultural systems.

Agro-sylvo-pastoral systems - systems in which land is managed for the concurrent production of agricultural and forest crops and for the rearing of domesticated animals. This system is, in effect, a combination of agri-silviculture and the sylro-pastoral system.

Multipurpose forest tree production systems - here forest tree species are regenerated and managed for their ability to produce not only wood, but leaves and/or fruits that are suitable for food and/or fodder.

All agroforestry land management systems have two essential and related aims: the systems should conserve and improve the site, and at the same time optimize the combined production of a forest crop and an agricultural crop.

Competition

The basic problem in agroforestry systems is competition. It might be useful, therefore, to examine the issue of competition among plant species, for it is important that the influences of tree crops on agricultural crops and vice versa do not counteract the positive influences of the forest ecosystem. In other words, it is necessary to ensure that competition among the different components of the system is not great enough to adversely affect the total productivity of the system.

As far as possible, the forest and agricultural species utilized in the system should be compatible and should complement each other in growth patterns over most stages of their lives. More specifically, with respect to water they should be unequal in competitive ability; they should vary in ability to utilize nutrients in different forms; those species should be selected that display growth patterns, rates of growth, phenology, and architecture that permit maximum interception of light by both the agricultural and forest crops at any one time, but that also minimize competition between the two groups of crops at all stages of their growth.

CHARACTERISTICS OF TREES FOR AGROFORESTRY

The characteristics of the tree species that should be grown in agroforestry systems have been listed elsewhere (King, 1979):

- they should be amenable to early wide spacement;
- they should be self-pruning,
- if not self-pruning, their photosynthetic efficiency should not significantly decrease with heavy pruning;
- they should have a low ratio of crown diameter to bole diameter;
- they should be light-branching in habit;
- they should be tolerant of side-shade, if indeed not of full over-head shade in the early stages of growth;
- their phyllotaxis should permit the penetration of light to the ground;
- their phenology, particularly with respect to leaf flushing and leaf fall, should be advantageous to the growth of the annual crop with which they are being raised;
- their rate of litter fall and litter decomposition should have positive effects upon the soil;
- their "above ground" changes over time in structure and morphology should be such that they retain or improve those characteristics that reduce competition for solar energy, nutrients, and water;
- their root systems and root growth characterisctics ideally should result in the exploitation of soil layers that are different from those being tapped by the agricultural species; and
- they should be efficient nutrient pumps.

This list of characteristics of the ideal tree species for use in agrisilvicultural systems is not exhaustive, but it indicates the principles that should be followed in the selection of such species. In addition, the known responses of the tree species to various management practices (such as pruning, thinning, and coppicing, for example) and to individual tree and stand manipulation must be recognized.

The same procedure should be followed for selecting the agricultural crop component of the system.

Put in another way, the plant architecture and morphology, the phenology of woody perennials, and the root distribution, root growth, and root activity of the those factors that affect net carbon fixation with respect to such factors as species differences, differing source/sink situations for annuals and perennials, and leaf and plant aging.

In addition, the influence of genotype and environment on dry matter distribution in herbaceous and woody plants; the effects of management on plant growth, dry matter distribution, and plant development; and the factors affecting the plant's nutrient needs and the distribution of nutrients within plants should be examined.

Much research needs to be conducted on:

- shade tolerance of agricultural species;
- identification of forest species that protect the soil but do not reduce energy levels on the forest floor;
- optimum spacing of both agricultural and forest crops under different ecological conditions;
- optimum species (agricultural and forestry) combinations;
- design of thinning regimes to optimize the yields of both the tree and agricultural crop; and
- design of pruning and logging regimes for the same purpose.

In addition, the following fundamental studies must be undertaken to underpin the field work described in the previous paragraph and to provide eventually a body of basic principles:

- dynamics of the various nutrient cycles that occur when the forest is cleared, during the cropping period, and during fallow;
- allelopathy and complementarity of various species;
- competition for solar energy among trees and between trees and agricultural crops;
- morphology and physiology of various tree species;
- leaf production and leaf fall of particular species, and the influence of their occurrence or competition for solar energy and the nutrient cycle.

SUMMARY AND CONCLUSIONS

I have ranged widely over the field of multiple-use research, and have attempted to draw attention to the need, in both developed and developing countries, to optimize production from a dwindling resource. I have attempted also to identify the research components in various multiple-use combinations. Often our knowledge of the effects of single-use forestry on the environment is inadequate, and one of the contributions to multiple-use management should be research on those aspects of single-use land management that are relevant to multiple-use. Concurrent with such research should be that conducted on the interactions of the various components. There should be a systems approach in tackling these problems. In other words, there should be two approaches: the single-use approach and the synthesizing, systems approach.

Finally, let us examine the economic evaluation of the service components of the multiple-use mix.

In spite of the unprecedented concern for the environment that has been experienced over the last 10 years, there has been little investment in conservation in developing economies (Muthoo, 1976). The hard-pressed governments of the Third World find it difficult to commit scarce resources to soil conservation and watershed protection, often because their advisors have failed to convince them of the economic benefits to be gained by conservation. Linked to this is our failure to quantify the physical effects of our failure to conserve.

Much progress has been made in the economic evaluation of the environmental effects of multiple-use management, and on quantifying the objectives of multiple-use management (Gregory, 1955). Multi-product indifference curve analysis has been suggested, the cost-effectiveness method has been applied in some cases (Price, 1972), the cost of substitution method has been advocated (Francios, 1962), as has willingness to pay (Maglin, 1962) ex ante evaluation, benefit-cost analysis, and a combination of market and nonmarket ratios (Muthoo, 1976).

In spite of all this activity, the impression remains that there is need for some research on the methodology of quantifying forest services and of relating them to multiple-use. There are limitations with respect to the issues of cardinal versus ordinal ranking and the additivity of ratios; the methodology of cost-benefit analysis appears to be in a state of flux; and many areas of multiple-use economics still seem to harbor conceptual difficulties.

This economic field is therefore worthy of greater research attention, and I hope that this conference will formulate a program of research in this important area.

Perhaps the most intractable developmental problem which faces both the developed and the developing worlds is the optimal development of its natural resources. In many cases the land, and the forests which occupy the land, are the most important natural resource. I believe that much of the poverty and misery which prevails in the developing countries is caused by their failure to realize the potential of these resources, by the fact that they have tackled the problems of land development and land-use in conventional ways, and by the fact that the practices they have adopted have not been based on sound research, have not been underpinned by basic investigations and knowledge.

I believe that multiple use research might offer some of the solutions to the socio-economic and physical problems we experience in this world. I am therefore extremely pleased that this Conference on Research on the multiple-use of forest resources has been organized. I am positive that your deliberations will lead not only to the enhancement of biological productivity in our forests, but also to increasing conservation of our natural resources.

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Banquet Address:

Multiple Use:

Its Growth from General Concept to Working Tool[1]

Douglas R. Leisz[2]

My purpose here tonight is to describe the multiple use backdrop for the research subjects of your conference.

From the standpoint of a decisionmaker, I can tell you that multiple use is reaching full flower in the United States. It's a concept whose time has come. World-wide, our growing demands are stretching the ability of the land to provide necessary goods and services without seriously compromising future productivity.

The Forest Service is particularly proud, as we celebrate our 75th Anniversary, of our part in transforming the idea of multiple use from a broad concept to a powerful working process for resource managers.

The roots of the concept in the U.S.A. go back 80 years or more. Eight decades have passed as the concept matured to a systematic approach for integrating development and conservation.

Because it is a concept, the term multiple use means many things to many people. So, let me offer you our definition.

It is a three-part definition, encompassing both space and time (1). It means different uses of adjacent subareas which together form a composite multiple use area. It also means the alternation in time of different uses of the same area. And finally, it can mean more than one use of management area at one time.

Multiple use moves from a concept to practice through the rigorous examination of the important ecosystem components of a specific area of land.

Multiple use in practice, is a systematic approach of determining and allocating a sustainable flow of goods and services in a predictable level of harmony for ecosystem components.

It's a systematic approach for integrating development with conservation.

Multiple use-sustained yield, in practice, requires a substantial base of knowledge for the resource manager.

As a minimum:

- ecosystem components must be known and understood.
- productive capacities must be defined.
- management standards must be embraced which ensure utilization, do not impair future productive capacity.
- we need to be able to model various combinations of uses to examine the effects on all important elements of the ecosystem, etc.

Two fundamentals must be noted at the outset. Multiple use management generally cannot be successful without an interdisciplinary approach. Public involvement--and understanding--are essential in helping decisionmakers identify alternatives and reach decisions.

Obviously, multiple use cannot be effective without the full support of research. Certainly, we need to know the potentials of the land, vegetation, water and animal life in various combinations of uses. And we need to have knowledge of the long-term effects, as well as the short-term yields that can be expected.

For a general perspective, let me trace the process that is still evolving in the United States.

The National Forest Organic Act set the stage in 1897 by proclaiming that some of the Federal Forests--then called Forest Reserves--would be managed to provide timber and to insure "favorable conditions of water flows" for the citizens of the U.S. (2).

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[1]Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.
[2]Associate Chief, Forest Service, U.S. Department of Agriculture, Washington, D.C.

The U.S. Forest Service was created in 1905 to carry out the management of these National Forests. The first Chief Forester, Gifford Pinchot, began championing the idea of several uses of the forest. Pinchot identified his concept of multiple use conservation to his small staff and to the Nation. Politically astute, he realized that a successful federal forestry agency needed support from the general public, as well as those who use the National Forests. "Programs he supported tended to have something for everyone...," notes one historian(3). His most famous pronouncement was his definition of conservation as "the greatest good for the greatest number in the long run."

As one Forest Service pioneer, Earle Peirce, says in his memoirs (4), "Although most foresters of the time had the idea of multiple use more or less in mind, there seemed little need or opportunity to put it into actual use, other than controlled use of the land for grazing."

In those early days, Forest Service planning and management were focused primarily on silviculture and grazing. By 1920, the Forest Service Manual had added major sections on timber management, grazing, fire protection, watershed, roads, and, for the first time, recreation. Recreation emerged strongly in the mulitple use picture in the 1920's as our road system developed in response to the growing use of the automobile.

At that time, the comparative isolation of the vast forests from the population centers kept use conflicts at a minimum. There was little need for concern over competing uses. There was still an abundance of land and resources--enough to meet all reasonable needs, although water supplies were significant local issue even 80 years ago.

That was to change in the next few years. Special use areas began to be set aside--scenic areas, geologic, botanic, and historic areas, natural areas, experimental forests and ranges, and wildernesses. The first National Forest wilderness in the Nation was created administratively in New Mexico in 1924. This was the "grandfather" of the Wilderness Act of 1964, the Roadless Area Review and Evaluation (RARE II) process we completed last year, and much of the current attention by Congress to wilderness--55 years later!

Planning helped to guide the expansion of uses. But the ingredient missing was well-integrated National Forest resource planning. By the late 1940's and early 1950's, such integrated planning began to take shape. One of the earliest such efforts took place in Southern California, where urban-rural tensions were evident even then. It was World War II, however, that set the stage for an effort to make mulitple use a National policy mandate--by law. As Edward Crafts, Forest Service Deputy Chief, put it (5): "With the great demand for timber, leaders of the Forest Service become concerend about the imbalance in Forest Service management and handling of various resources."

Congressional direction was needed to help the Forest Service cope with increasing pressures to overcut, overgraze, or otherwise overuse the renewable resources of the National Forests.

The culmination of efforts by many people was the enactment of the Multiple Use-Sustained Yield Act of 1960 (6).

The new law focused National attention on multiple use and sustained yield management of public lands. It stated clearly that the National Forests would be administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes. Expounding a major principle, Congress decreed that the establishment and maintenance of areas of wilderness is consistent with the purposes and provisions of the Act. The law prescribed "harmonious and coordinated" management of the various resources, without impairment of the productivity of the land.

The strengths and limits of that law are still being argued, tested and refined. During the past 20 years--and, of course, before--there was much misunderstanding and some disagreement, as might be expected. Critics had a tendency to argue that the Forest Service could not manage for all of the multiple uses on each and every acre. They overlooked the ideas of a changing mix of uses over time, the interrelationships of different uses on adjacent areas, and the balancing of mixture of compatible uses on specific areas.

The 1960 law encouraged the Forest Service to further integrate land management planning. Planning was already part of the Forest Service fabric--but primarily along functional lines--timber, range recreation, wildlife, transportation systems, for example. The integrated planning mechanisms began to take shape. They were stimulated even more by enactment of the National Environmental Policy Act of 1969 (7). This Act refined the planning process by requiring strong interdisciplinary analysis and significant public involvement in the formulation and review of plans. It required a visible decision process.

Two more recent major pieces of legislation added scope and intensity to land management planning. They provided the legal foundation for the practical application of multiple use as a living, working principle. They were the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) (8) and the National Forest Management Act of 1976 (9).

The heartbeat of both is comprehensive, integrated, balanced, longrange planning. Together they provide the framework for all National Forest planning, as well as achieving a long-needed integration of research and State and Private Forestry planning into an agency-wide approach.

This, then, is where we are today.

The obvious question you might ask is: "With this experience with multiple use-sustained yield, does it work?"

The answer, is clearly "yes." We have many truly exciting on-the-ground examples of how the public benefit is optimized by skillful blending of resource uses. Proper application ensures maintenance of the resource productivity base.

Another obvious question is: "Does it eliminate user conflicts?"

The answer here is "no," but it does provide a systematic, rational approach to managing all the resources, It usually does minimize conflicts, and it allows the examination of the effects of selected resource uses before the practices are applied.

Development of multiple use has been a painful evolution at times. But when our present generation of plans is completed, we think they will be worthy models for consideration by forest and range managers all over the world. One reason for this is the evolution of the technology that enables us to apply this concept effectively.

We have come a long way since 1960. In my experience in California in the 1960's, our progress was triggered by a major movement of urban society onto the wildlands. There, the forest and chaparral ecosystems were badly abused through forcing urbanization on ecosystems unable to support such uses. The conflicts and the forced adjustments to them accelerated. Multiple use became the most obvious and supportable approace to attempt to deal with the problem.

We are still far from the ideal of balanced, harmonious use of our lands--both public and private. Critics point to examples where the elasticity which multiple use offers has been exceeded. The restults in a few cases have been unacceptable, despite our good intentions.

We know now that this approach cannot be stretched too far--either by lack of sufficient knowledge, by inadequate analysis, or by poor execution of programs. We also believe that the aggregate of benefits which can be accrued through a multiple use-sustained yield approach are greater than the products or services of a set of dominant or single uses.

The viability of multiple use is also proven in the crucible of non-federal resource management. It has been adopted to a considerable degree by States, by industry on its lands, and even by small, nonindustrial landowners.

We are pleased that international interest in multiple use is also growing. It really is reflected in many of the intensively managed forests of other countries (10). As come of you probably remember, the Fifth World Forestry Congress in 1960 used multiple use as its theme.

More recently, the potential benefits of multiple use-sustained yield were given even broader international attention with the announcement by IUCN in March 1980 of the World Conservation Strategy (11) commissioned by the United Nations Environment Program and the World Wildlife Fund. Its forestry goal is a strong recognition of multiple use, as a tool "to ensure the earth's capacity to support its growing population" through "sustainable production."

Let me restate the obvious once more:

Multiple use-sustained yield can only be as effective as the knowledge that underlies its use. The scientific community that is represented here tonight can strengthen this foundation.

This is our hope--and it is my challenge to each of you.

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Session I

Research Techniques for Developing Multiple-Use Information

Carl Berntsen, Moderator

Society of American Foresters, USA

One of the most profound statements made by Dr. Kenneth King in his keynote address was that it is time we developed sound research evidence that multiple-use management is possible for a variety of situations. The panel on Research Techniques focused on this theme by describing research on multiple use in specific situations; by showing the need for such research in a given area; and by describing a method for predicting multiple-use benefits.

Dr. G. F. Weetman, Canada, demonstrated the value in using simulation models for two boreal forest research problems: cutover yield production in wild unmanaged stands, and prediction of the effects of nutrient exports on forest productivity. The models provided insight into the probable stand and ecosystem development.

A. B. Villa Salas, Mexico, submitted a paper on "The establishment of experimental areas for intensive research on multiple use" which was presented by Dr. Arturo Gomez-Pompa. This paper described the biological, physical, and social characteristics of the Sonoran River basin in northwestern Mexico. The topographic variation from low-elevation arid lands to the alpine conifer forests of more than 2500 meters in elevation presents an ecological complex that requires a multidisciplinary scientific team to carry on multiple-use research. The intermingling of small communities and dispersed "Campesinos" requires that sociologists and economists also be a part of the research team.

Dr. B. N. Okigbo, Nigeria, laid the background for his paper on "Multiple-use research in Africa" by reviewing the tropical African environment: The rapid population growth; the clearing of land for food, fiber, fuelwood, and timber; and the characteristics of developing countries. He pointed out that the scope of multiple-use research should cover structure, functioning, and processes in a natural ecosystem in comparison with the conditions and changes resulting from management strategies.

Mr. W. A. Kermani, Pakistan, presented a paper on "Multiple-use practices in arid regions". He explained that agro-forestry practices are distinctly advantageous over the former system of planting forestry crops only. He listed 9 benefits that can be realized from such practices.

The last paper was presented by Dr. S. Boyce, USA, on "Predicting multiple benefits from silviculture". He described an orderly way to plan, control, and direct the transformation of forests from one state to another. This orderly transformation provides time-varying variables -- the temporal and spatial dispersion of habits -- that can be used to predict the potential for any and all benefits singly and in combination.

Techniques to Study Ecosystem Development[1]

G. F. Weetman[2]

Abstract--The value in using simulating models is demonstrated for two boreal forest research problems: cutover yield prediction in wild unmanaged stands, and prediction of the effects of nutrient exports on forest productivity. In both cases the dynamic nature of the models, in spite of their crude nature, has provided insight into the probable stand and ecosystem development and added credence to current concerns about future forest productivity associated with these problems. It has also suggested productive lines of research.

Introduction

I would like to discuss two problems in ecosystem development in Canada that are of considerable practical interest. The first is that of predicting the yields of commercially clear cut virgin forest stands; the second is that of long-term nutrient balance following full tree harvesting. The current rate of harvesting in Canada is approximately one million hectares per year, most of it in virgin forests that have developed following natural catastrophic events such as fires, windthrow and insect attack. There is currently considerable national concern over long term wood supplies. The supplies are calculated by whole-forest computer models which must assume valid yield functions to be reliable. There is increasing evidence that empirical yield curves based on historical natural stand development are not valid for cutover stands. The advent of mechanized logging, with greater site disturbance, and particularly advanced growth destruction, has resulted in much conversion from pure conifer to stands of mixed species composition, with long regeneration periods, patchy stocking and often irregularly aged and structured stands. It is presently not feasible to plant all the cutover stands.

In addition, the labour saving advantages of mechanized full-tree harvesting are very attractive for remote areas. Additional nutrient exports from the site, by removal of branches and tops to roadside, are also of concern because of possible reductions in long term site fertility.

[1]Invited paper for the IUFRO/MAB Conference Research on Multiple Use of Forest Resources Flagstaff, Arizona, May 1980.

[2]G. F. Weetman is Professor of Forestry, University of British Columbia, Vancouver, B. C. V6T 1W5 Canada.

A. Problem 1: Cutover Yield Prediction

Conventionally reproduction surveys examine stocking and density of conifers. Standards have been set, assuming certain combinations of both, which are assumed will ensure future full stocking and an adequate yield function, but it is doubtful that the assumptions are valid. Four approaches to yield prediction can be used:

1. To empirically relate the results of old regeneration surveys to subsequent stand development. Unfortunately, the relationships are often poor.
2. To examine pole sized stands, in order to reconstruct stand conditions at ages 5 to 10. This is very difficult with mixed stands.
3. To ignore young stand development and wait until the stand structure has stabilized before yield predictions are made. Unfortunately, the yield projections of the millions of hectares in the 0 - 20 age class are needed now.
4. Develop stand development simulation models which "grow" cutover stands based on mathematical assumptions about crown development and space requirements of individual stems. The output of such models is tested against conventional yield functions.

This latter approach is desirable and I will give an example based on 10 years of measurements on 36 cutover pulpwood stands in Eastern Canada (Frisque, Weetman and Clemmer, 1978). The model was designed to project stand development into the future on a wide variety of black spruce, balsam fir, jack pine and mixed wood cover types that have received no silvicultural inputs before or after logging. Figure 1 gives a simplified flow chart.

The model requires a time frame, at five year intervals; a moisture regime determination, for conversion to site index; the mean height diameter

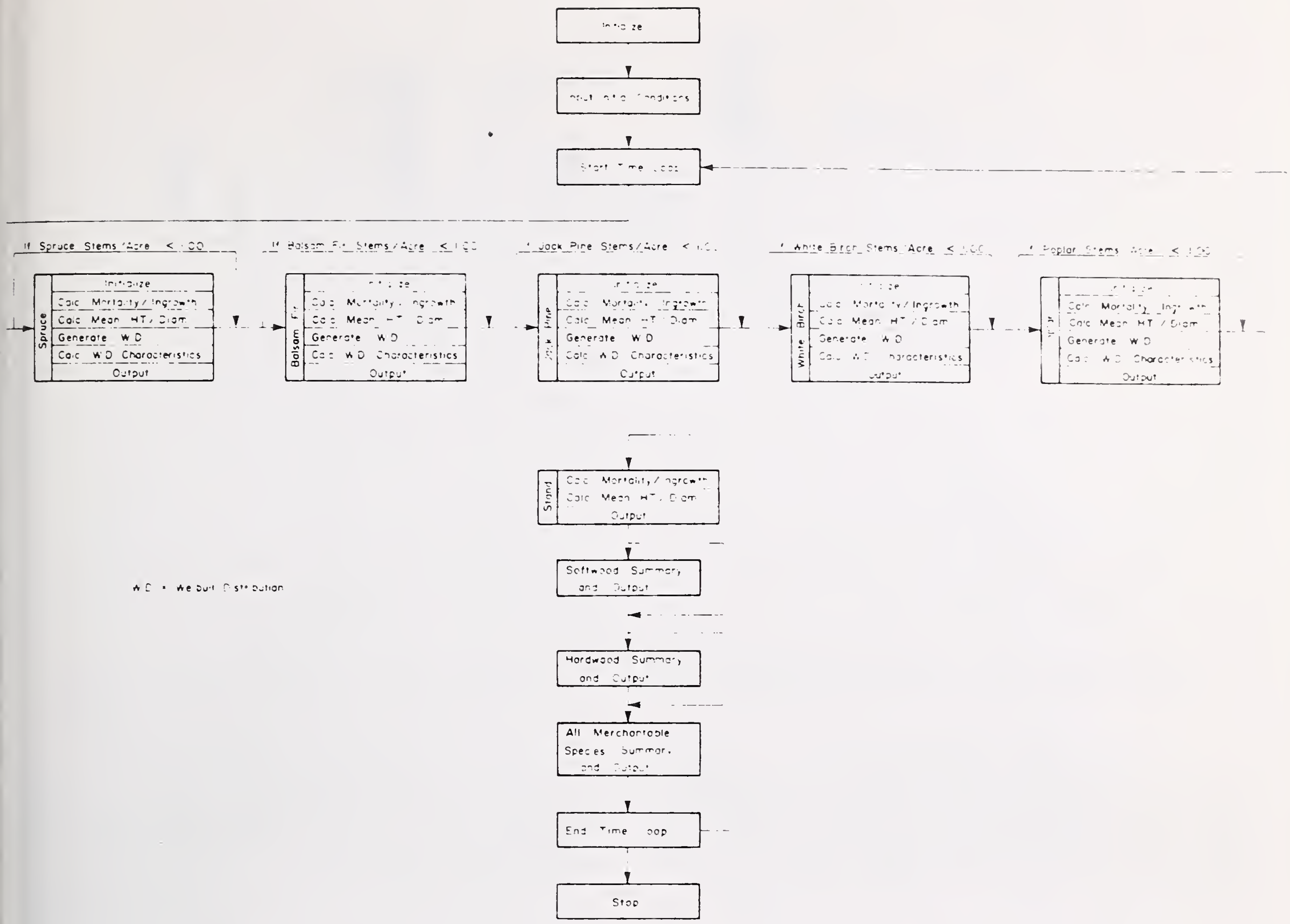

Fig. 1.-- Simplified flow chart of a stand development model to predict cutover yield in eastern Canadian pulpwood yields (from Frisque, Weetman, and Clemmer, 1978).

class and stems per acre of the merchantable species and of all the species including shrubs; and a series of constants to determine maximum height diameter growth of the whole stand.

The model then runs dealing with: 1) mortality and ingrowth using a competition index; 2) height-diameter growth; 3) height diameter class distribution using a Weibull function; 4) stand parameters of mortality and ingrowth and of the potential height diameter growth.

The model is very constrained; at best it is merely a comparative measure of cutover development across Eastern Canada.

Figure 2 compares the softwood/hardwood stocking to "best specimens" at age 10 with the softwood/hardwood basal area ratio at age 50 obtained by simulation. Figure 3 gives commercial species stocking at age 10 and simulated yields of commercial species at age 50. The figures show that: 1) tallies of the dominant "best-specimen" of reproduction are well related to simulated "mixedness" of the stand; 2) low best-specimen stocking is associated with low simulated yields.

In this study, the use of the model was particularly valuable in adding credence to foresters' claims of very serious future yields of poorly stocked pulpwood cutovers. Subsequently, this problem has developed into an area of major national concern for Canada (Reed, 1979).

B. Problem 2: The Prediction of the Effects of Nutrient Exports on Forest Productivity

This is a very old, almost classical, forestry problem, with its precedents going back to litter raking in Europe in the last century. More contemporarily, the removal of full trees in modern logging due to biomass needs or the exigencies of mechanized logging have renewed interest in this old problem.

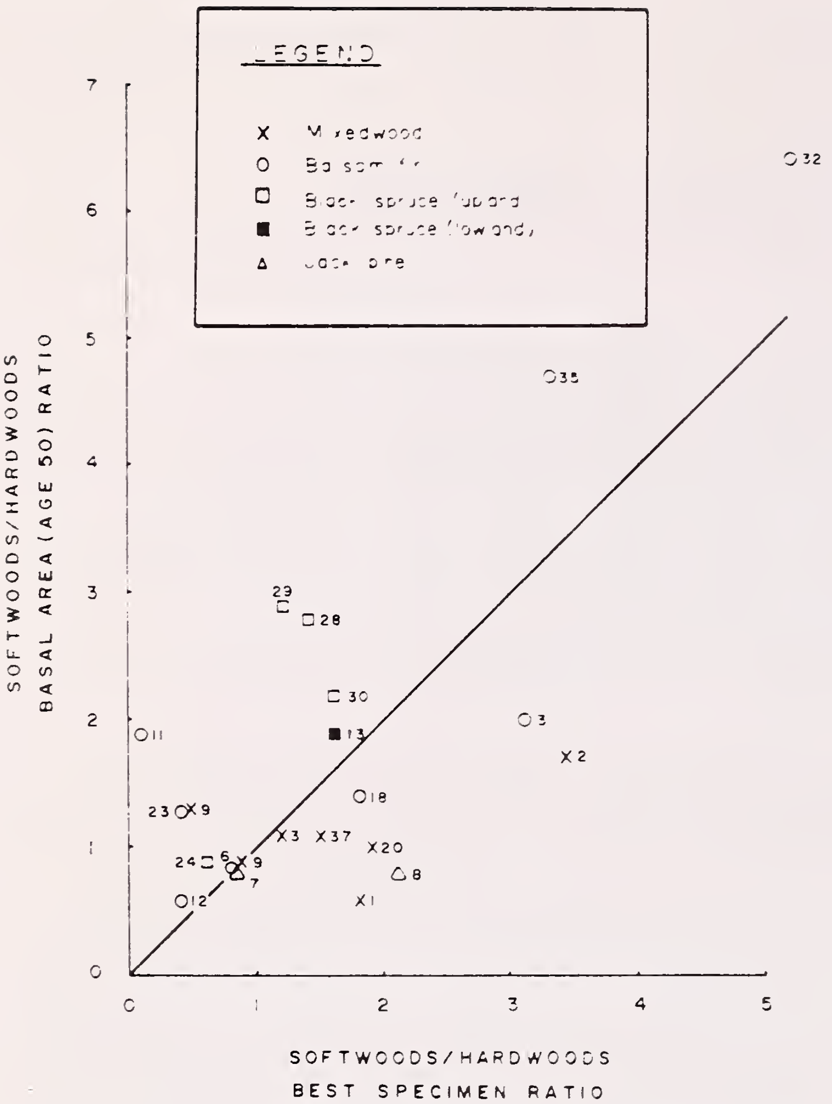

Fig. 2.-- The relationship between softwoods and hardwoods best specimen ratio at age 10 and softwoods and hardwoods basal area ratio obtained by stand simulation to age 50 (from Frisque, Weetman, and Clemmer, 1978).

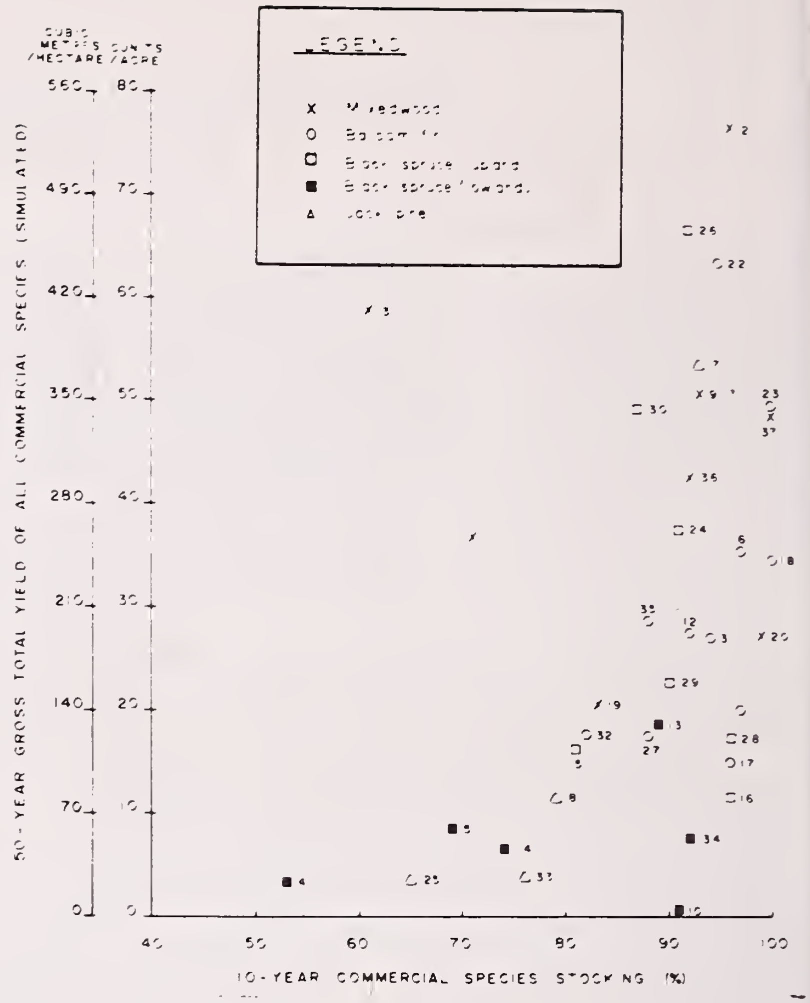

Fig. 3.-- Relationship between stocking of all commercial species at age 10 and simulated yield of all commercial species at age 50 (from Frisque, Weetman, and Clemmer, 1978).

A fundamental aspect of the problem is our lack of ability to relate readily measurable forest soil analysis techniques to forest productivity. In old forested ecosystems the fertility is largely related to the dynamics of the nutrient cycling rather than the point in time and space type of conventional soil nutrient analysis. For northern forests, nutrient availability is largely mediated by microbial activity in humus decomposition, which in turn is related to temperature, species composition of the litter, soil moisture regime and composition of soil parent materials.

Three approaches to the nutrient balance problem are possible:
1. Develop a 'static' balance sheet of inputs, stand and soil contents and losses of major elements based on soil "available" or "exchangeable" nutrients.
2. The same, but based on "total" nutrient contents in the soil.
3. Attempt to develop a dynamic simulation model which "grows" the forest--taking into account inputs, cycling rates, losses and factors controlling nutrient release during stand development.

Figure 4 shows an example of a static balance in a black spruce stand (Weetman, Clemmer and Algar, 1979). It is very difficult to make any predictions from such a static balance.

Figure 5 shows a simplified component model of nutrient balances using computer simulation. The model consists of four major components that involve an estimation of:
1. biomass nutrient demand
2. the biogeochemical balance composed of inputs from geochemical weathering and precipitation balanced against run-off losses
3. biological inputs of nutrients from overstory and understory litterfall, logging residues, and internal nutrient cycling
4. the net nutrient balances as a result of demand (component 1) being balanced against supply (components 2 and 3).

The purpose of the model, therefore, is to compare the supply of nutrients with the demand for nutrients by the biomass at progressive points in time. The approach is to compare nutrient supply with nutrient demand rather than allowing the two processes to interact. In addition, the absolute

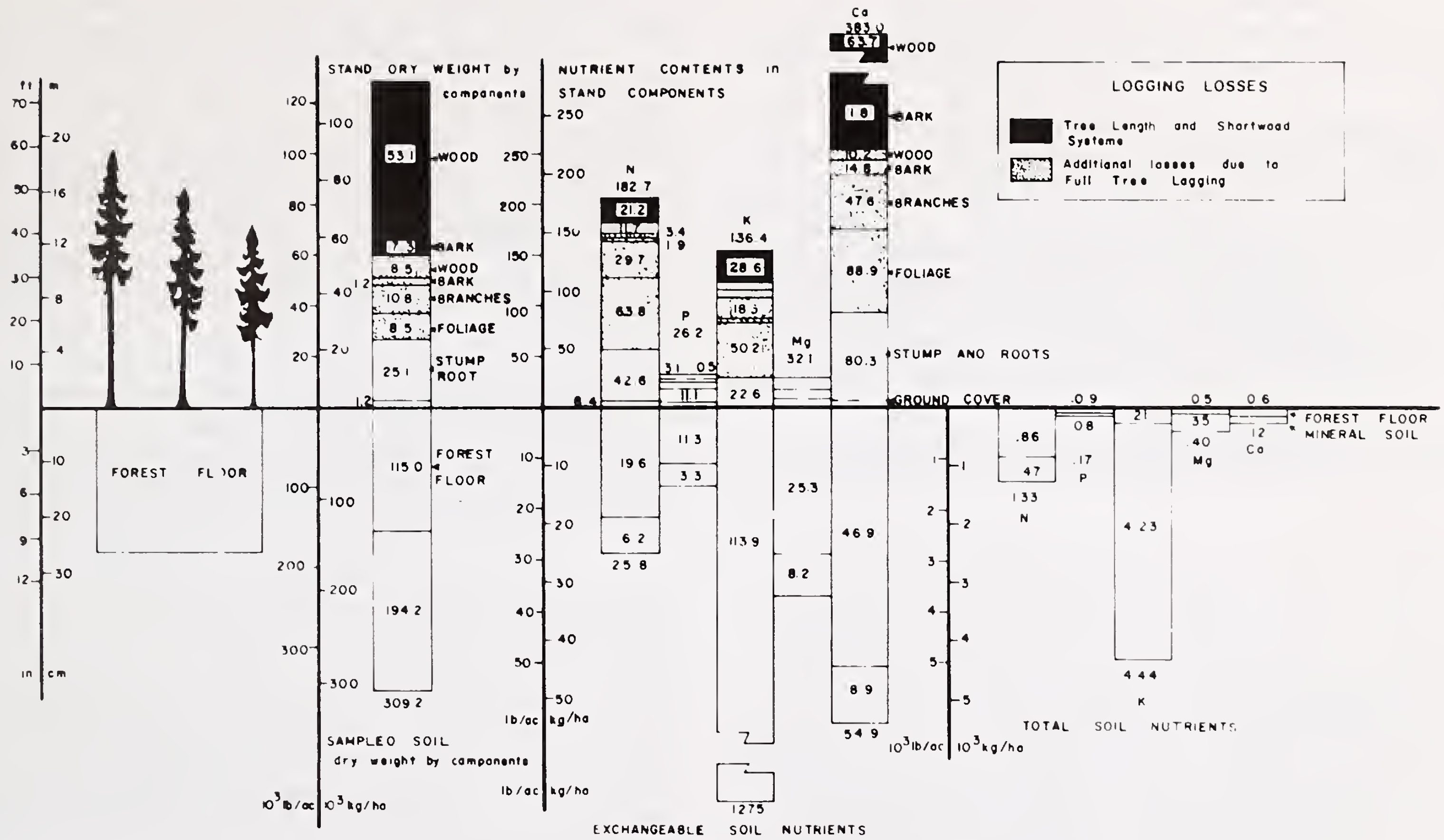

Fig. 4.-- Dry weight and nutrient content of soil and stand components (kg/ha). Black spruce (*Picea mariana*) stand, 200 years old, Baie Comeau, Quebec (from Weetman, Clemmer, and Algar, 1979).

precision of the model on any given site subjected to any given harvesting regime, can be readily called into question because of the amorphous data set, drawn from a wide variety of sources in the literature, that has been used to construct the model. However, the model as presently developed, possesses a very high degree of generality, and is able to evaluate nutrient balances in the next rotation over a wide range of boreal conifer types subjected to a wide variety of harvesting regimes. Finally, the model does represent, even with its lack of dynamism, a more sophisticated and effective method of dealing with the problem of nutrient balances following logging than the static balance sheet approach typically used in the literature.

The simulation model was used:
1) to compare the effect of softwood, full and complete tree logging on the nutrient balances in the next rotation on the black spruce and jack pine sites under study using the most likely inputs for the biogeochemical processes and the most likely mineralization curve for the transfer from the residual soil pools to the available soil pools;
2) to compare the relative influence of the biogeochemical processes and the mineralization rate on the nutrient balances in the next rotation on the two sites when:

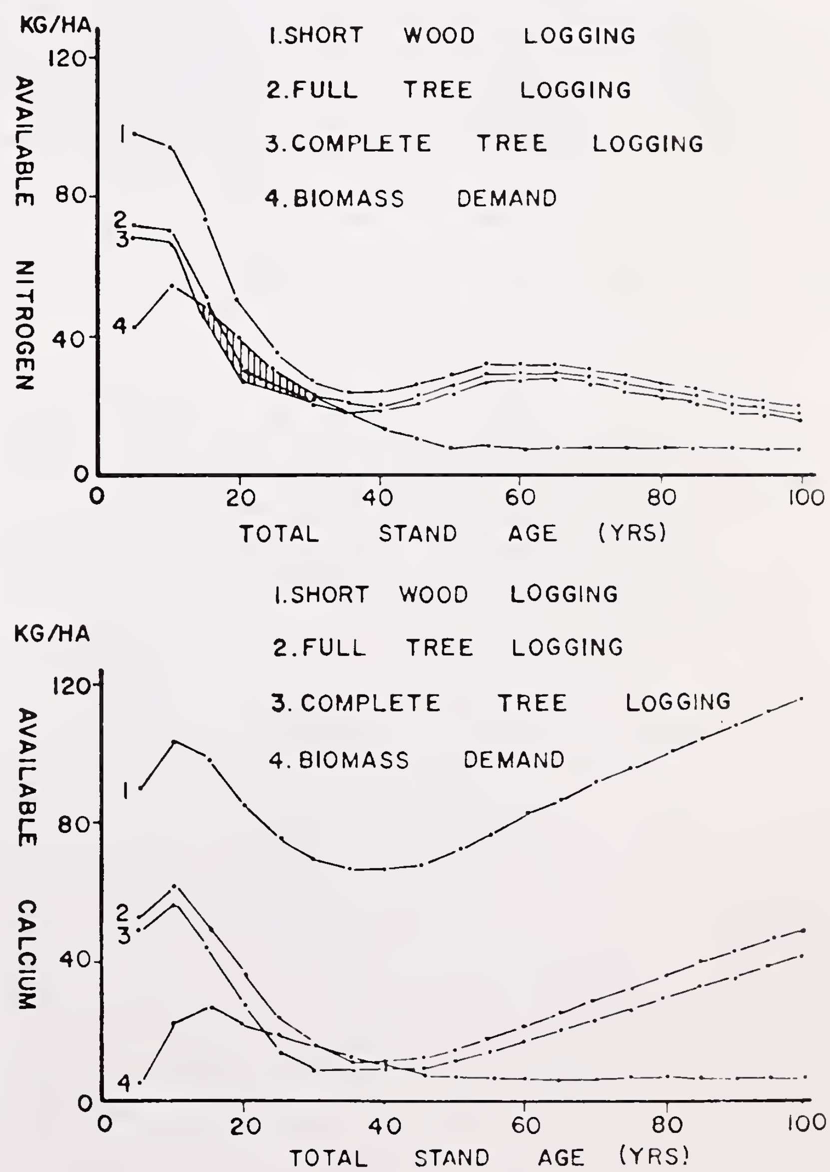

Fig. 5.-- Simulated nitrogen (upper) and calcium (lower) balances in the next rotation on black spruce Site Class IV in the boreal forest. (From Weetman, Clemmer, and Algar, 1979).

(a) the biogeochemical balance was either optimized or minimized while the mineralization rate was held constant at the most likely level;
(b) the mineralization rate was optimized to the higher and lower curves while the biochemical inputs were held at the most likely levels.

3) examine with the existing computer program using the most likely biogeochemical inputs and the most likely mineralization curve for the nutrient balances in the next rotation on better quality sites following shortwood, full and complete tree logging.

Figure 5 indicates the simulated nitrogen and calcium balances in black spruce Site Class IV.

The output from the nutrient balance model indicated that using the most likely biogeochemical inputs, and the most likely residual soil pool to available soil pool mineralization curve, nutrient deficits would develop in the next rotation following full or complete tree logging on:
a) the jack pine, and both the good and poor spruce sites, in nitrogen and calcium,
b) the good quality red spruce-balsam fir site in phosphorus. With shortwood logging, such nutrient deficits developing in the next rotation would be eliminated or substantially reduced in magnitude and duration.

Nutrient deficits developing in the next rotation after full or complete tree logging were attributed to the non-return of logging residues, particularly the readily decomposable needle mass. This leads to a substantial reduction in initial soil pools relative to shortwood logging, with the result that nutrient deficits develop across a range of macronutrients. This problem is progressively compounded as the proportion of the site's nutrient capital tied up in the plant biomass and vulnerable to removal increases.

The absolute magnitude and duration of the nutrient deficits that develop in the next rotation cannot be better quantified without better and more precise estimates of the biogeochemical inputs and the rate of mineralization of the residual soil pools to the available soil pools since the nutrient balance model was shown to be highly sensitive to these parameters

In this case the main value of the model has been to identify the most likely information gaps.

This has been done by testing the model for its sensitivity. The importance of the organic matter decomposition and biochemical inputs was already suspect. The model has led further credence to the current recommendation to avoid full-tree logging on poor sites in the boreal forest, characterized by thin humus layers or with low cation exchange capacity.

While the two examples of the use of models were designed for forecasting and studying timber and nutrient dynamics, future stand conditions are of considerable interest for studies of wildlife populations and nutrient losses in watersheds.

Cover type conversion of extensive areas from conifers to mixedwoods and hardwoods is particularly important for moose, deer, beaver, and other furbearing animals. Crude estimates of browse production are possible from the cutover development model. Estimates of hardwood component development are valuable for estimates of changes in nutrient availability, seasonal snowmelt, and the rate of development of nutrient sinks to conserve nutrients following cutting.

For boreal forest areas with low population pressures, a surplus of fresh water, a tough climate for recreation, and with difficult access, multiple-use conflicts have not been great.

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TECHNIQUES POUR ETUDIER LE DEVELOPPEMENT D'UN ECOSYSTEME

La valeur dans l'emploi des modèles de simulation est démontrée pour deux problèmes de recherche en forêt boréale: prédiction du rendement de coupe dans les taillis sauvages non-aménagés et la prédiction des effets de l' exportation d' éléments nutritifs sur la productivité forestière. Dans les deux cas la nature dynamique des modèles, malgré leurs nature rudimentaire, a fourni un apercu du developpement probable de taillis et d' écosystèmes et a ajouté créance aux soucis courants concernant la future productivité forestière associée avec ces problèmes. Elle a aussi suggeré des productives lignes de recherche.

TÉCNICAS PARA ESTUDIAR DESARROLO DES ECOSISTEMAS,

Se demostró la validéz del uso de modelos simulados para dos problemas de investigación forestal en bosques boreales: predicción de la produccion por tala rasa de los bosques virgenes y predicción de los efectos de la perdida de nutrientes en la productividad del basque. En ambos casos la dinámica de los modelos, a pesar de su estado inicial oprimitivo, ha profrorcionado: percepción del probable bosque y desarrollo del ecosistema; validéz a la actual preocupacion acerca de la productividad futura del bosque asociado com estos. Los problemas y sugiere lineas de investigación efectivas.

METHODEN ZUM STUDIEM DER ENTWICKLUNG VON EKOSYSTEMEN

Die verwendungswert von Simulationsmodellen wird für Forschungsproblemen zweier nördlichen Wälder demonstriert: Sowohl die Vorhersage des Ertrags in natürlichen, unbehandelten Beständen nach dem Kahlschlag, als auch der Effekt des Verlusts von Pflanzennährstöffen auf der Produktivität des Waldes. In beiden Fällen, hat die dynamische Beschaffenheit der Modellen, trotz ihres rohen Zustands, Einblick in die wahrscheinliche Entwicklung des Bestands und Ekosystems gegeben. Zusätzlich, gibt das System Glauben an den gegenwärtigen Interresen in die zukünftige förstliche Produktivität, die mit diesen Proplemen assoziert sind. Die Modellen können auch weitere Forschungsrichtlinien andeuten.

Multiresource Management Research in Northern Sonora[1]

Avelino B. Villa-Salas[2]
A. Cecilia Mañon-Garibay[3]

INTRODUCTION

In Northern Sonora the misuse of natural resources has resulted in large areas of overgrazed and eroded lands. Rainfall on bare soil is increasing surface runoff, carrying the fertile soil. This action is gradually reducing the soil capacity and the soil itself.

The erosion process which starts in the upper part of the watershed is increasing the sediment level not only of the Sonora river basin but also in the downstream dams. One of those, Abelardo L. Rodríguez Dam, is the main water reservoir in the area. It is part of the Hermosillo Irrigation System, and feeds fresh water to Hermosillo City.

The soil mass movement and sedimentation are directly affecting agricultural, cattle, and forestry production. At present the Federal Government is carrying out some flood control and stream conservation work, though the results have not been estimated.

The Under Secretariat of Forestry and Wildlife, in its forest research programs, has started collecting information to establish a program of multiresource management in the Sonora River Basin. The goal is to obtain a sustained yield of water, forage, timber, recreation, and wildlife.

RESEARCH AREA

Locality

The Sonora River basin is located between 29° and 31° North Latitude and 110° 45' and 111° West Longitude.

The area of the basin is about 2,911,000 hectares (7,193,000 acres).

[1] Paper presented at the IUFRO/MAB Conference: Research on Multiple Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona. Paper read by Arturo Gomez-Pompa, Director General, Department of Biotic Resources, Xalapa, Mexico.

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[3] Researcher, Multiple Use Project, National Institute for Forestry Research, Secretariat for Agriculture and Forestry Research, Mexico City, Mexico.

Hydrology

The Sonora River begins at the peaks of the Los Ajos, Buenos Aires, and Cananea mountains. The Arbajo spring, near the town of Cananea, starts the permanent stream of the Sonora River, and also provides fresh water to Cananea.

Climate

There are three main types of climate, determined primarily by elevation:

Temperate, subhumid with main rain season during summer. The mean annual temperature varies from 13 to 18° C, and the annual rainfall varies from 550 to 750 millimeters. The area is covered with pine forest.

Arid temperate, with rain season during summer. The mean annual temperature varies from 18 to 22° C and the annual rainfall varies from 400 to 550 millimeters. The characteristic vegetation is a brush-grass association.

Arid subtropical, with rain season during summer and winter. The mean annual temperature varies from 18 to 20° C and the annual rainfall varies from 350 to 400 millimeters, -C (wo)-. At this elevation the main vegetation type is grassland.

Soil

Although soils vary with topography and parent material, they can be classified in three broad groups:

In the highest part of the mountains, soils developed *in situ* from igneous, rhyolitic, basaltic, and schist rock, with an abundance of micas. Soil color varies from grayish to dark grayish brown, its depth varies from 10 to 15 cm, the texture varies from sandy to clayey sandy, and there are abundant gravel and stones in the soil and over its surface. They are well drained and are rich in organic matter in the top layer.

In the foothills region, soils are characterized by their reddish brown or pale brown color; the texture varies from a loam to a sandy clay, with a neutral or slightly alkaline pH. These soils are not too deep, immature, with 40 to 50% of gravels and stones, and some exposed bedrock.

In the grassland region, the parent materials include granitic, metamorphic, and sedimentary rocks. Depending on how they were formed, there

PHOTOS, Top to Bottom:

Pine forest.

Oak stand at the foothill of "Los Ajos" mountain.

Overgrazed grassland.

are colluvial and alluvial soils, with shallow or middle depth. Color varies from dark brown to grayish, the texture varies from sandy to sandy clayey loam, and there are gravels and stones in the soil and over its surface.

Vegetation

There are also three main types of vegetation, determined primarily by elevation.

Pine forest vegetation grows from 1,800 up to 2,500 meters above sea level (5,900 up to 8,200 feet). The main species are: Pinus chihuahuana, P. engelmanni, P. ayacahuite var. brachyptera, P. reflexa, P. arizonica. The brushy vegetation is represented by "manzanita" Arctostaphylos pungens, and the most abundant grasses are Bouteloua sp, Aristida sp., and Muhlenbergia sp.

Pine-oak forests, from 1,500 up to 1,800 meters above sea level (4,920 up to 5,900 feet). The grasses at this elevation are overgrazed.

Grassland with shrub vegetation occurs from 1,250 up to 1,550 meters above sea level (4,100 up to 5,080 feet). The main grasses are Bouteloua curtipendula, B. chondrosioides, and B. filiformis. The lower part of the grassland and hilly areas support three main subgroups of vegetation:

Thorny bush vegetation. The main species of this group are:

Prosopis sp.	Mezquite
Fouquieria splendens	Ocotillo
Cercidium microphyllum	Palo verde
Olneya tesota	Palo fierro
Jatropha cinerea	Torote
Opuntia leptocaulis	Tasajo
Carnebia gigantea	Saguaro
Baccharis sarathroides	Romerillo

PHOTOS, Top to Bottom:

Cresosotebush.

Exposed bedrock in pine-oak forest.

Desert creosotebush, represented by:

Larrea tridentata	Gobernadora
Prosopis sp.	Mezquite
Fouquieria splendens	Ocotillo
Acacia sp.	Guisache
Opuntia sp.	Choya
O. laptocaulis	Tasajillo
Baccharis sarathoides	Romerillo
Bouteloua hirsuta	Zacate
B. gracilis	Zacate navajita

Thorny forest. The representative species of this group are:

Prosopis laevigata	Mezquite
Acacia sp.	Acacia
Cordia sp.	Anacahuita
Lysilloma sp.	
Caesalpinia sp.	Hierba del Potro
Fouquieria splendens	Ocotillo
Cassia sp.	Casia
Jartropha cinerea	Torote
Opuntia sp.	Nopal
Cercidium sp.	Palo verde
Encelia farinosa	Rama blanca

RESEARCH PROJECT

Due to the varied problems in the Sonora River Basin, the research project takes into consideration both short and long-term goals.

One of the first tasks is to determine the synecological characteristics of the area and the ecosystem's level of perturbation. On the basis of this knowledge, management alternatives will be ascertained.

In the first phase of the study, the "producers" will be studied in order to determine their diversity in species composition, density, distribution, dominance, and frequency.

In a parallel fashion, the main characteristics of the "consumers" will be determined. Later, the soil microorganisms will be analysed.

The present study will be focused on the major vegetation types of the area.

The soil and climate will be studied in a complimentary work with the aid of topographic maps. Some types of information expected to be assessed from the soil study are: erosion level, organic matter content, fertility, texture, structure. infiltration rate, and erosion susceptibility. The climate study will measure rainfall, temperature, relative humidity, and light.

One of the main objectives will be to specify the population demand on goods and services. Once the ecosystem has been described, it will be possible to select the management level needed to obtain the potential yields from the soil.

The management of the basin will be centered around a multiple use approach toward forest resources in such a way as to produce water, forage, timber, wildlife, and recreation.

From the information obtained up to now, it is possible to foresee some additional research topics:

1. Introductory tests with shrub forage species such as Kochia and Atriplex.

2. Stream control and soil management by using vegetative covers.

3. Forest plantations for soil stabilization and to produce timber for regional use such as plant protectors, fence poles, and construction timber.

4. Soil management and sedimentation control.

5. Range management.

6. Levels of sedimentation and water quality.

7. Endangered species.

8. Wildlife habitat.

9. Technological characteristics of different woods.

10. Present and potential markets for wood products.

11. The use of wood as a construction material; nature and characteristics of such use.

12. Present and potential possibilities for recreation.

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INVESTIGACION SOBRE EL USO MULTIPLE DE LOS RECURSOS FORESTALES EN EL NORTE DE SONORA

En la cuenca del Río Sonora el excesivo uso de los recursos está perjudicando el ecosistema.

La acción de la lluvia y las corrientes superficiales sobre la tierra desnuda reduce su fertilidad y también produce mucha erosión. El azolve así producido está dañando a ríos y presas. Tal es el caso de la presa Abelardo L. Rodríguez, de donde se abastece de agua potable la ciudad de Hermosillo, y es base del sistema de riego del mismo nombre.

Este hecho afecta la producción agropecuaria y forestal, también como la economía de la población.

Por estos motivos la Subsecretaría Forestal y de la Fauna ha iniciado los estudios para implantar un programa de uso múltiple de los recursos forestales para obtener una producción constante en base a forraje, agua, madera, fauna silvestre, y recreo.

La investigación de la cuenca del Río Sonora se enfocará a corto y largo plazo.

El estudio sinecológico del ecosistema permitirá establecer su grado de deterioro. El análisis de esta información y de las demandas de la población humana, permitirá elegir el grado de manejo que se aplicará a los recursos naturales.

Dada la demanda de la población en bienes y servicios, los recursos naturales se manejarán bajo el concepto de "uso múltiple de los recursos forestales."

Con el propósito descrito se han iniciado estudios sobre la delimitación de la cuenca y subcuencas y sobre las características de la relación clima-suelo-vegetación.

En base a la información disponible se prevee tomar las siguientes acciones:

-Medición de escurrimiento, azolve, y calidad de agua.

-Corrección y control de cauces.

-Manejo de vegetación.

-Manejo de suelos.

-Experimentación con especies forrajeras y forestales.

-Estudio sobre fauna silvestre.

-Estudio de mercado e industrialización.

-Protección de especies en peligro de extinción.

RECHERCHES SUR L'USAGE MULTIPLE DES RESSOURCES FORESTIERES DANS LE NORD DE SONORA

Dans le bassin du fleuve Sonora, l'usage excessif des ressources naturelles, affecte gravement l'ecosystème.

L'action de la pluie et les courrants superficiels sur le terrain nu, non seulement sont en train de réduire la fertilité du sol mais en outre arrache de grandes quantités de terre. L'eau ainsi alterée nuit aux fleuves et aux reservoirs.

Tel est le cas du reservoir Abelardo L. Rodríguez que fournit l'eau potable à la ville d'Hermosillo et qui forme la base du système d'arrosage du même nom.

Le fait dèjá décrit affecte la production élèvage et forestière et donc l'économie de la population.

Pour les raisons ainsi exposées, la "Subsecretarí[a] Forestal y de la Fauna" du Mexique a déjà commencé les études pour inaugurer un programme d'usage multiple des ressources forestières pour obtenir une production constante de fourrages, d'eau, de bois, de faune silvestre et de récreation.

La recherche du bassin du fleuve Sonora est envisagé à courte et à longue date.

L'étude sinecologique de l'ecosystème permettra d'établir son degré de dégradation. L'analyse de cette information et des demandes de la population humaine permettront de choisir le degré de maniement qu'on s'appliquera aux ressources naturelles.

Etant donné la demande de biens et de services de la population, les ressources naturelles seront administrés dans le domaine d'usage multiple de ressources forestières.

Avec un tel but, on a commencé les études sur la limitation du bassin et des sous-bassins et sur les caractères de la relation climat-sol-plantes.

Sur la base de l'information disponible on pense prendre les actions suivantes:

-Mesure de l'égouttement, de l'altération et de la qualité de l'eau.

-Correction et contrôle des lits.

-Maniement de la végétation

-Maniement des bois

-L'expérimentation avec les espéces de plantes fourrages et forestières.

-L'étude de la faune silvestre

-L'étude du marché et d'industrialisation.

-Protection des espéces en danger d'extinction.

AUF ZAHLREICHEN QUELLEN BERUHENDE MANAGEMENT FORSCHUNG IN NORD SONORA

Die uebermaessige Nutzung der natuerlichen Ressourcen im Einzugsgebiet des Río Sonora laesst schon jetzt eine ernsthafte Stoerung des Oekosystems erkennen.

Niederschlaege und Ueberschwemmungen auf voellig ungeschuetzter Oberflaeche haben nicht nur einen Rueckgang der Bodenfruchtbarkeit zur Folge, sondern bewirken auch einen grossen Verlust an Bodensubstanz. Die daraus resultierende Verlandung beeintraechtigt sowohl Flusslaeufe als auch Stauseen negativ. Letzteres trifft auf den Stausee Abelardo L. Rodríguez zu, der die Stadt Hermosillo mit Trinkwasser versorgt und die Grundlage fuer das Bewaesserungssystem eben dieser Gegend bildet.

Dieser Vorgang wirkt sich unmittelbar auf die land- und forstwirtschaftliche Produktion aus und damit auf die wirtschaftliche Lage der Bevoilkerung.

Aus diesen Gruenden hat das Staatssekretariat fuer Forst und Fauna Studien eingeleitet, um ein Programm der Vielfachnutzung von forstlichen Ressourcen einzufuehren um auf diese Weise eine tragfaehige, langfristige Basis fuer die Produktion von Futter, Wasser, Holz und Fauna zu haben und um gleichzeitig der Erholung der Bevoelkerung zu dienen.

Diese Untersuchung des Einzugsgebietes des Río Sonora ist sowohl unter kurz- als auch langfristigen Aspekten programmiert.

Eine erste Studie soll zunaechst den Grad der Beeintraechtigung des Oekosystems feststellen. Die Analyse der so gefundenen Information sowie der Ansprueche der Bevoelkerung an dieses Oekosystem wird es erlauben, den Nutzungsgrad der natuerlichen Ressourcen festzulegen.

Unter Beruecksichtigung der Nachfrage der Bevoelkerung nach Guetern und Dienstleistungen wird eine Verwendung der natuerlichen Ressourcen nach den Grundzuegen der "multiplen Nutzung" der forstlichen Ressourcen angestrebt.

Unter dieser Zielsetzung wurden Studien ueber die Abgrenzung des Einzugsgebietes und seiner Subregionen begonnen, ebensowie ueber die Charakteristika der Beziehung Klima, Boden, Pflanze.

Ausgehend von der verfuegbaren Information sind folgende Massnahmen vorgesehen:

Messung der Oberflaechenbewaesserung, Verlandung und Wasserqualitaet.

Korrektur und Kontrolle von Wassergefaellen.

Pflanzen-Management.

Boden-Management.

Experimente mit Futter- und forstlichen Pflanzen.

Studien zur Fauna.

Markt- und Industrialisierungsstudien.

Schutz der Arten, die sich in Aussterbensgefahr befinden.

Development of Multiple-Use Management for Tropical Forests Through Research in Africa[1]

Bede N. Okigbo[2]

Modeling and simulation offer opportunities for understanding and predicting effects of different management systems. Studies are to be located in selected sites representative of relevant ecosystems or benchmark areas within the forest zone of concern.

Africa, the second largest continent, two thirds the size of Asia, extends 8000 km from 35° north and south of equator and 7500 km from about longitude 51° east to 17.5° west with a total land area of 3030 x 10^6 ha (van Chi-Bonnadel, 1973, Sanchez, 1976 and Best Blij, 1977). It consists more or less of a compact - plateau with an average elevation of 425m in the north and over 900m to the south rising from a narrow coastal plain by a series of escarpments from sea level to 5960m on Mount Kilmanjaro. A complex drainage pattern of rivers traverse rapids in running down the edge of the escarpments in their lower courses to the sea. Several areas of internal drainage and the lakes of the rift valley upset the normal drainage pattern.

Mean annual temperatures except in the extreme north and south exceed 20°C but decrease with altitude at a rate of 1°C per 150m. Annual rainfall varies from less than 400mm in the Sahara and Kalahari deserts to over 5000mm in Southern Cameroons. Most of the west coast of Africa, Zaire and Central Africa has annual rainfall of from 1000 to 3000mm. Areas up to 1400mm or more annual rainfall and 100mm or more monthly rainfall in 9.5 - 12 months have tropical rainforest, areas with annual rainfall of 400 - 1400mm in 4.5 - 9.5 months have deciduous forest and savanna vegetation while areas with less than 400mm annual rainfall in 0 - 4.5 months support thorny shrubs, trees and desert (Sanchez, 1976, Glove and Klein, 1979).

Soils of tropical Africa are generally highly weathered and of low to medium native fertility except on younger volcanic soils and poorly drained hydromorphic and valley bottom soils (Entisols and Mollisols). According to Donahue (1970) percentage areas covered by the various soil groups consist of Aridisols (32%), Alfisols (23%), Oxisols (22%), Entisols (11%), Inceptisols (6%) and Ultisols (4%). Under forest vegetation most of the nutrients are tied up in the vegetation which on clearing results in exposure of soil to erosion and structural degradation.

The area of tropical rainforest in Africa amounts to 300 x 10^6 ha as compared to 1260 x 10^6 ha of savanna and 1212 x 10^6ha of desert. Of the world's 4,100 x 10^6ha of forest, 202.5 x 10^6 (27%) are located in Africa as compared to an equal area and percentage in Asia and 345 x 10^6ha (46%) in Central and South America (UNESCO, 1975). Forests and flora of tropical Africa are known for (1) their relative poverty in number of species per unit area, (2) wider distribution or less localization of species, and (3) poverty of African forests in certain plant families, e.g. Palmaceae and Lauraceae. Despite this limited diversity of species only very few forest trees are being exploited. Multiple use management research must remedy this.

Africa is relatively poor in bird fuana as compared to tropical America Bourliere (1973). For example, Skid (1960) and Moreau (1966), report 182 and 266 species of birds in the West African and Congo forests respectively as compared to 269 species resident in 5 km^2 area of Costa Rica. The number of families, genera and species of mammals in Africa are similar to those in Latin America but tropical Africa is relatively poorer in bats and rodents; rich in forest primates in both areas as South America and undoubtedly richer in ungulates than Latin America. The savannas of East and Central Africa are markedly richer in wild life than the savanna and forests of West Africa as a result of greater disturbance by man. Roughly 40 out of 50 African countries and over 300 million people with annual population growth rates of 2 - 3.5% are located in tropical Africa (Ralzer, 1975). About 21.8% of population of Africa are located in urban centres as compared of over 5,000 people as compared to 25.4% and 54.4% for Asia and south America, respectively (Mabogunje, 1976). Africa has the highest rate of urbanization (5%) in the world which is double the world average. Population density is 8.6/km^2 as compared to 66/km^2 for Asia. Most areas are sparsel peopled except for concentrations of up to 1000/km^2

[1] Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.

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parts of West Africa (e.g. southeastern Nigeria), Nile Valley, in lower Egypt and around Lake Victoria.

Of the total land area of 2212 x 10^6ha in tropical Africa, 166 x 10^6 (8%) is cultivated, 652 x 10^6ha (29.5%) are in meadows and pastures while forests cover 571 x 10^6ha (25.5%), Sanchez (1976). Although the cultivated land area of 0.5 - 0.6ha per capita is double that for tropical Asia, the Pacific and South America, there is rapidly increasing pressures on the land since increasing land area under cultivation remains the principal method of increasing food production for the rapidly increasing population. About 70% of the population of Africa is engaged in subsistence agriculture. Within the last three decades intensification of agricultural production has resulted in almost total replacement of shifting cultivation by bush, woodland and grassland fallows. Over 80% of the wood products in tropical Africa is used as fuel wood and thatch. Major foreign exchange earners are plantation crops such as rubber, cocoa and oil palms, arable cash crops such as cotton and groundnuts, timber and minerals. Tourism based largely on planned development of beaches and coastal areas as in Ivory Coast or on wildlife safaris and game parks as in East Africa is of some economic importance in certain countries. Infrastructural development in relation to settlement, roads, dams for hydroelectric and irrigation purposes, certain human activities such as annual burning of vegetation and the different colonial, political and socio-economic background of countries of tropical Africa which has resulted in different land tenure and agricultural systems and development strategies are factors which must be taken into account in consideration of the need and strategies for research on the development of multiple use management of Africa's tropical forest.

MULTIDISCIPLINARY NATURE AND SCOPE OF RESEARCH ON MULTIPLE USE OF FOREST RESOURCES

Forests constitute renewable natural resources. They are vital components of man's support system (Odum, 1972). Forests are an integral part of the biosphere which conceptually may be regarded as a mosaic of ecosystems in which man exists. According to Odum (1972) the integrated management of ecosystems and the populations of man they support poses the greatest challenge ever faced by man. Integrated management of the ecosystem can only be attained through understanding of the structural components of the ecosystem consisting of (1) inorganic substances in the materials cycle; (ii) organic compounds that link biotic and abiotic components, (iii) the climatic regime (iv) autotrophs, mainly green plants, (v) phagotrophs or macroconsumers, and (vi) saphrophytes in addition to processes involving (1) energy flow circuits, (ii) food chains, (iii) diversity patterns in time and space and (iv) nutrient or biochemical cycles.

An understanding of the various factors and processes involved in the different developmental stages of an undisturbed ecosystem in comparison with developments in portions of the same or similar ecosystems subjected to different management packages related to human needs and/or objectives is the basis of research in forest or other ecosystem management. This involves monitoring of changes, quantifying of observations on complexity interacting factors and establishing inter-relationships among them so as to permit modelling of the processes and prediction of outcomes of different management strategies. It is obvious that research involving studies of ecosystems and development of principles for their management must be multidisciplinary and necessitates contributions and interactions among taxonomists, meteorologists, ecologists, physiologists, agronomists, soil scientists, economists, engineers, etc. Moreover, with increasing pressure on Africa's forest resources any research on multiple use of forest resources must also involve isolation, study and bringing into regular cultivation of indigenous wild, protected or cultivated plants that have hitherto not received the attention they require.

Scope of Research Activities

The complex nature of problems of development of multiple use management systems for tropical forests and the need for multidisciplinary problem-oriented research have long been recognized. Yet under normal conditions baseline data collection and other relevant studies have been the result of often isolated individual discipline studies by ecologists, botanists, soil scientists, physiologists, etc. Teams of two or three scientists may sometimes be involved but very rarely are the necessary multidisciplinary teams used. Research activities for the development of multiple use management of tropical forests in Africa or elsewhere in the tropics and the physical (climate, geology, soils, etc), biological (vegetation analysis, action of wild and domestic animals, etc.) and socio-economic (land use, population density, socio-economic structure,etc) data to be collected and measurements on related variables in the assessment of conditions of the ecosystems, processes and interactions thereof are detailed in Nye and Greenland (1960), Thomas and Whittingham (1969), NAS/NRC (1969), Ellenberg (1971), Dassman, Milton and Freeman (1973), Farnworth and Golley (1973) Golley and Medina (1975) and various UNESCO MAB reports. All these emphasize the need for research activities which encompass:

a) evaluation of existing conditions, present uses and ecological changes taking place in tropical forests;

b) impact of land use alternatives on the fertility of tropical forest ecosystems;

c) effects of loss of biological diversity in the tropics;

d) effects of human settlements on the tropical forest;

e) epidemiological impacts of tropical forest land usages on man, domestic animals, wild animals and man;

f) effect of tropical land manipulations on the cultural and behavioral characteristics of human groups living in the region;

g) development and application of models for optimization and production in tropical forest regions (UNESCO MAB 1972).

These studies will involve periodic forest inventories to determine forest distribution and changes, monitoring of changes in animal and plant populations, soil conditions, etc. under different management regimes. It is obvious that research to facilitate this is multidisciplinary and should involve contributions and interactions among meteorologists, taxonomists, ecologists, physiologists, economists, agronomists, soil scientists, biochemists, engineers, foresters, etc. Although projects such as MAB and other less comprehensive forestry and agroforestry projects exist there are almost no integrated ecosystem management studies of sufficient scope at national and regional levels in Africa.

OBJECTIVES AND DESIGN OF EXPERIMENT

The objectives of research for multiple use management of tropical forests constitutes a problem or challenge of discovering ways of disturbing the natural ecosystem for the benefit of man without jeopardizing the rich source of biological information of tropical forests (Farnworth and Golley, 1973). Research aimed at achieving this objective is be focused on the evaluation of input/output relationships, sustained yield and consequences on environmental quality of various resource and input manipulations related to alternative land uses (Table 1). This involves study of natural undisturbed forest ecosystems in comparison with different management systems and associated environmental and input manipulations related to the alternative strategies in Table 1. Ideally, research activities associated with these alternative strategies should be multidisciplinary and should involve coordinated teams of scientists tackling the problems simultaneously. There are at present few if any integrated ecosystem management studies of sufficient scope as to cover most of the relevant alternatives listed in Table 1 in any one African country. This is partly due to the shortage of trained manpower at various levels, limited resources to support such studies and tradition of tackling problems and training along disciplinary lines. However, it is still necessary and possible to organize well coordinated studies in interdisciplinary teams in existing national and international institutions. Nationals and 'expatriate' scientists could participate in such studies. For example, in Nigeria while there are studies in forestry institutions on forest ecosystems and their management, it is only in agricultural institutions that detailed studies on soils and soil fertility maintenance are being carried out. The work is not restricted to national institutions. For example, at IITA there are studies in forest clearing effects on subsequent cropping systems and soil fertility and erosion in relation to

Table 1.-- Alternative land use possibilities for multiple-use management research in Tropical Africa.

1. Conservation a) Water management
   b) Gene pool, etc.

2. Special Reserves a) Hunting and fishing
   b) Tourism, etc.

3. Forestry for Timber a) Natural forest management
   b) Selected indigenous species
   c) Selected exotic species
   d) Single indigenous species
   e) Single exotic species

4. Tree Crop Plantations
   a) Tree crop intercrops (coconut, cocoa, etc)
   b) Tree crops (rubber, oil palms)
   c) Shrubs (cocoa, coffee)

5. Tree and Shrub Fallow Systems
   a) Shifting cultivation
   b) Bush fallow systems
      i) Natural fallows
      ii) Planted fallows (several species)
      iii) Planted fallows (single species)

<u>Special Agroforestry Systems</u>

6. a) Traditional taungya (similar 5a or 6)
   b) Indigenous tree/annual or perennial crop intercropping
   c) Tree forage crop intercropping with livestock
   d) Exotic tree/perennial and annual crop intercrop

7. Short Term Herbaceous Perennial and Annual Fallows

8. Grazing Land a) Miscellaneous shrubs and grasses
   b) Grasses and legumes
   c) Grasses only
   d) Legumes only

9. Annual Crops
   a) Mixed crops + short duration (1-2 year) fallow
   b) Mixed crop rotation fallow (rare)
   c) Mixed crop + sole crop rotation
   d) Sole crop + short duration (1-2 year) fallow
   e) Sole crop continuous

10. Industrial Uses

11. Mining

12. Human (settlements)

cropping and tillage systems. Individual single disciplinary studies can also effectively contribute to these studies. For example, work by Okafor (1976) has made available improved indigenous planting materials for agroforestry multistoried intercropping systems at IITA and surveys associated with his work hame generated data on role of trees in farming systems.

Multiple use research cannot be carried out everywhere and the sizes of countries and regions to which some of these are relevant varies. Therefore, it is necessary to restrict studies to sites, plots, watersheds, etc. which are representative of larger areas, zones, regions or basins to which results obtained from smaller sample areas can be extrapolated. As long as adequate measures are taken in selection of sites, use of statistical designs and standardization of procedures and quantification of observations, it would be possible to determine inter-relationships among variables and extend results based on smaller models to larger areas. It is however, necessary that as far as possible, the various studies involved should be well coordinated from planning stage to execution.

MANAGEMENT OF MULTIDISCIPLINARY RESEARCH TEAMS

Studies of components of ecosystems such as mineral or water cycles let alone studies of whole ecosystems, or catchments used in research on multiple-use of forest resources necessitate use of one or more teams of professionals in various disciplines. The situation may range from studies carried out by a team of individuals in the same institution to those involving individuals or teams from different institutions in one or more countries. Even where individuals in the team are from the same institution, there is need from the beginning (i.e. during the planning stage) to ensure not only the coordination of activities of several individuals in various disciplines but also the coordination of activities in time and space covered by the study so as to facilitate the project being executed as an effective entity.

As soon as the project is conceived, it is of vital importance to seek out individuals in the relevant range of disciplines who are qualified and experienced but above all are willing to actively participate in the project. Each participant is made to realize from the beginning that it is necessary for him or her to function in such a way as to (1) satisfy the individual's disciplinary and career opportunities, (ii) satisfy the requirements of other participants in either services to be rendered or in making activities mutually compatible, and (iii) be ready to share in exchange of data with others and participate in mutual evaluation of collective results of members of the team. Ellenberg (1971) represents a worthwhile example of what can be achieved in a well organized and coordinated project of this kind. It is necessary that while each participant is in a position to satisfy his own special interest, he is also able to identify them with those of others and the common objective(s). The value of the data collected and the uses to be made of them will depend on the extent to which everyone in the team cooperates by fulfiling their assigned and expected functions. Thus each participant must have and recognize his or her role in the project. This may include coordination or other assessory roles in addition to the special individual disciplinary functions. These functions are all agreed to by all concerned so that no one feels that anyone is giving orders or exercising undue control over others. A few examples from IITA may serve to illustrate ways of setting up, organising, collecting data and evaluating them in such projects.

An integrated watershed management study at IITA involves agronomists, agricultural engineers, agricultural economists, soil scientists, foresters plant and protection scientists. All these are represented in various activities from the planning stage to the evaluation and presentation of the results. During the planning sessions everyone is involved in the discussions of objectives, site selection and preparation, design of experiment, treatments, timing of various operations, equipment, observations to be made. procedures and methods to be adopted, evaluation procedures, etc. Everyone contributes to the final decisions taken and the plan that is evolved. Someone acts as leader who on the basis of experience, review past work and consultations with others, produces a paper on which discussions are based. Sources of funds are also discussed, inter-agency participation is considered and individuals to be invited to join are proposed. For example, both the Department of Forest Resources at the University of Ibadan and the Forest Research Institute of Nigeria were brought in to carry out the inventory of plants in relation to numbers, sizes, and distribution in a 15-20 year forest fallow. Decision was then made on the clearing techniques to be used for the different blocks in relation to the treatments to be applied subsequent to clearing. The planting plan was based on results of an earlier pilot toposequence study and on the general planting plan indicated in Figure 1.
It was decided that in addition to the planting patterns and sequences of crops to be used on different contours, an evaluation of different levels of technology or input mixes based on the unit farm concept was to be super-imposed. Project leadership and coordination was assigned to an agricultural economist and unit farmers were selected to manage the different units. Work on the project at different stages in different parts of the field involved different disciplines and individuals. Data was collected on labour, various inputs used, convenience and problems associated with different operations, yields, general crop performance, competition of various operations with other demands on the farmer's time and resources, etc. The evaluation included a cost/benefit

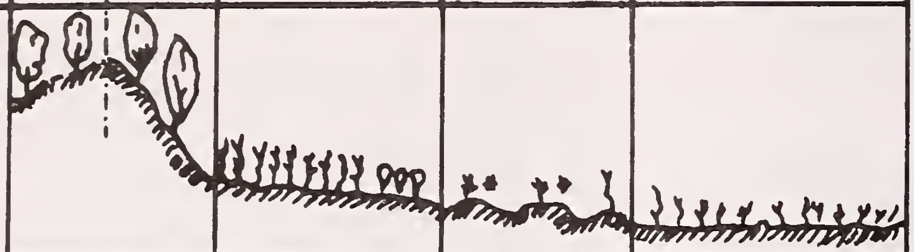
SOIL-SLOPE ZONES	UPPER/STEEP 'UZ' 'SZ' SLOPES	MIDDLE SLOPES 'MZ'	TOE SLOPES 'TZ'	BOTTOM SLOPES 'BZ'
				
CROP RANGE	Perennials e.g. Oilpalm, Coco-o, Coco-nut, Rubber, Kola Fruit-tree, Timber and kindling	Cereals Maize, Rice (upland) Sorghum, Millet Grain-Legumes: Soya, Cow-pea Mung, Pigeon-pea Roots: Cassava Sw-Potato, Vegetables: Melon, Okra	Cereals Rice, Maize Roots: yams Coco-yam Cassava Vegetables: Peppers, Tomato.	Cereals Rice (flood-irrigated) Vegetables: (raised bed)
PRE-PLANTING OPERATIONS	Contour-platforms Cover-crops	'Zero'-or-minimum-(strip) tillage (and /or herbicide	Ridges; Raised-beds	Tilled and levelled (bunded); Herbicides Ridges/raised beds
IRRIGATION	Rain	Rain, Sprinkler	Rain; Sprinkler; Trickle	Rain; Flood; Furrow.
PLANTING/ SEEDING	Manual	Seed: 'Jab' or 'Propelled' Planter; average spacing: Rice - 25 x 25 (150,000/ha.) Legumes - 25 x 50 (100,000/ha.) Maize - 25 x 75 (50,000/ ha.) Roots: Manual - 100x 100 Mechanised - 150 x 65		
CONTROL	Herbicide	Herbicide: Pre-planting .... Contact ,, Pre-emergent) - .... Selective ,, Post-emergent) ,, Inter-row .... Contact Manual Inter-row .... Mechanical		

Fig. 1.-- Illustrates typical soil-slope zones in the humid-tropics and the range of crops generally suited, with the corresponding tillage-planting-weeding practices appropriate to each. (Wijewardene R. 1976)

analysis and prediction on the economic viability of enterprises based on the different unit farms (Tables 2 and 3)

Meetings were held at the planning stage, subsequent to each planting season and at the evaluation of data prior to preparation of the reports on the studies to be presented during the annual seminars. Operations to be carried out, equipment to be used, methods and techniques adopted, etc. were discussed ahead of time. Data and descriptions of observations were shared prior to the seminar for presentation of results. Sometimes it was found necessary to visit the site during discussions on various activities and the results. The general experience in the project indicated that:

(i) it is necessary that participants should be those who are willing and prepared to generate data, identify themselves with the project and are ready to share data and experience.

(ii) all likely participants should be contacted early and brought into the project from the beginning; bringing in participants midstream should be avoided.

(iii) there should be a meeting during planning to discuss the objectives, methods, techniques,

Table 2 Management levels of five unit farmers Established in an integrated watershed management.*

	M1	M2	M3	M4	M5
Varieties	V_o	V_1	V_1	V_1	V_1
Crop Systems	C_o	C_o	C_o	C_1	C_1
Land Management	L_o	L_o	L_1	L_2	L_2
Fertilizer	F_o	F_o	F_1	F_2	F_2
Weed Control	W_o	W_o	W_1	W_2	W_2
Mechanization	M_o	M_o	M_1	M_2	M_3
Paddy Development	I_1	I_2	I_2	I_2	I_2
Ha/Unit of Labor	.3	.3	.3	.6	1.2

Subscripts in increasing order represent higher improved levels of technology; eg for varieties V_o = local, V_1 = improved variety.- for weed control W_o = Hand weeding, W_1 and W_2 alternate levels of herbicide.

Source: IITA Annual Report, 1977.

problems envisaged, etc. so that all concerned are associated with the final decisions reached; other meetings should be scheduled during some of the crucial stages of the project.

(iv) each participant has a well mapped out role to play and is convinced not only of his or her role in relation to his discipline but also of services he or she may render to others and to the whole project.

(v) someone should be the leader of the project and responsible for coordination and arranging for certain activities that fall between disciplines.

(vi) standardized procedures on data collection, the range of data to be collected, methods of evaluation etc, should be worked out beforehand.

(vii) in surveys and collection of socio-economic data, local scientists or enumerators should be used where strangers or expatriates may arouse suspicion; this enhances reliability of the data collected.

TABLE 3: Average maize and paddy yields in two seasons and annual output and gross income for three units over two production years 1977-1978 in relation to toposequence position of crops and levels of technology*

Toposequence and season		Level of technology I - IV	V	Maize and Rice Yields I	II	III	IV	V
UPPER SLOPES								
1	Season	Maize/cassava	Maize	1280	2080	2600	2420	2650
2	Season	Cassava	Maize	530	-	1090	1200	1170
3	Season	Maize/cowpea	Cassava	-	-	-	-	-
TRANSITION ZONE								
1	Season	Yam		-	-	-	-	-
2	Season	Yam		-	-	-	-	-
3	Season	Plantain/cocoyam		-	-	-	-	-
VALLEY BOTTOM								
1	Season	Rice	Rice	905	2035	4015	3580	3280
2	Season	Rice	Rice	-	-	-	-	-
3	Season	Vegetables	Not used	-	-	-	-	-
Total maize + paddy yields				2715	4115	7705	7200	7100
Average annual gross income				$1431	-	$1989	$2432	-

Source: IITA Research Highlights, 1978

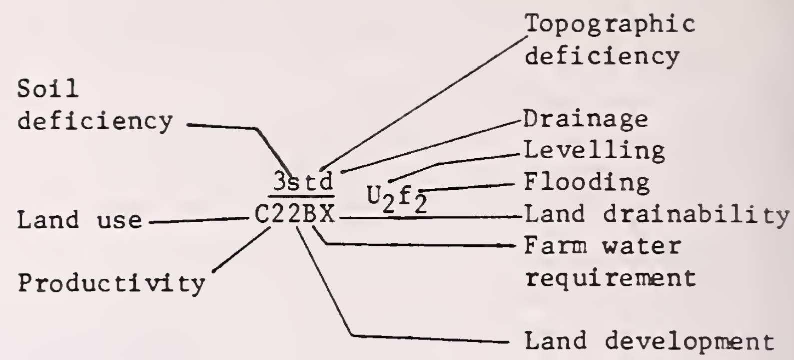
(viii) timing of collection of data and the evaluation and presentation of data should be carried out in such a way as to involve participation of all who made the collective results possible; but one should also ensure that the time allowed for the collection and presentation of the results affords opportunity to observe seasonal and other sources of variation that may manifest themselves so as to give a clearer idea of true life situation.

SIMULATION MODELS IN TROPICAL FORESTS MULTIPLE USE RESEARCH

Although the use of modelling techniques in ecology and agriculture is relatively new, it is now recognized that mathematical models are useful tools in (l) providing insights on inter-relationships within an ecosystem, (ii) providing a conceptual framework for understanding the system, (iii) facilitating forcasting of changes in the system in relation to various manipulations related to different management strategies, (iv) affording opportunities for integration of effects of different processes within the system and (v) providing a means of optimising of resources management (UNESCO, 1972, Farnworth and Golley, 1973). In general, in addition to enhancing understanding of a system and its functioning, modelling is effective in the prediction of possible outcomes of various management strategies thereby guiding decisions in ecosystem management.

For modelling to be feasible data on such variables as biomass of plants and animals, number of species of organisms, concentration of nutrients at successive intervals, observations on climatological factors etc. must be rendered in quantitative terms so as to enhance establishment of inter-relationships mathematically or graphically between various processes or between such quantities as production and environmental factors at different periods.

For modelling to be meaningful, detailed observations must be made on all relevant physical, biological and socio-economic factors and processes but above all, such observations must be based on some logical stratification or classification. The area to be studied should first be classified into regions corresponding to certain ecosystems or features in the ecosystem. Forests may be classified into different forest or ecosystem types. Land may be classified on the basis of such characteristics as profile features, texture, chemical reaction, organic matter content, available nutrients, depth; topography (elevation, degree of slope, aspect and climate, (rainfall amount and intensity temperature, climatic hazards, etc. (King, 1977). Some mapping symbols and criteria used in land classification are as follows:



Standard mapping symbols and components for Land Classification Surveys of U S Bureau of Reclamation (Olson, 1974).

Land capability classes useful to foresters and agriculturists are presented in Tables 4 and 5.

Table 4.-- Land Capability Classes

Class	Suitable for cultivation
I	No risk, only good management necessary
II	Some risk, moderate conservation practices necessary
III	Considerable risk, intensive conservation practices necessary
IV	Great risk, best for perennial vegetation and infrequent cultivation
Class	Suitable for pasture, hay, woodland, wildlife
V	No restriction
VI	Moderate restriction in use required
VI	
V	No restriction
VI	Moderate restriction is use required
VII	Severe restrictions in use required
VIII	Suitable only for wildlife and recreation

Source: Constantinesco, 1976.

TABLE 5: Soil fertility capability groupings of alfisols, ultisols in West and Central Africa*

Soils (great group)	Parent materials or rocks	Land form or topography	Textural type[1]	Condition modifiers
		I. Alfisols		
Paleustalfs Plinthustults	Granitic gneisses Granites Quartz-schists	Rolling to undulating	LL or LLR	e t* m* r w d
Paleustalfs	Coastal sediments Sandstones	Flat to undulating	LL	e t* w d
		II. Alfisols and Oxisols		
Paleusutults Plinthustults	Coastal sediments Sandstones, shales	Undulating to rolling	LL or SL LL or SL	e h k w d r t*
Paleudults	Coastal sediments	Flat to undulating	LL or SL	e h k a* k t*
Paleudults Tropudults	Granites Quartz-schists Acid gneisses	Rolling	LL, SL, LLR	e h k a* t* r
Tropohumults Tropudults Tropohumox	Basalts Diabases Amphibolites	Rolling to hilly	LC, CC	e k i h*
Haplorthox	Old alluvium	Level river terrace Small upland plateau	LL, CC	e k h a* t*
		III. Hydromorphic soils		
Aquolls Aqualfs	Colluvium or alluvium	Inland valleys	SLR, LLR, LL	q f
Aquults Aquox	Colluvium or alluvium	Inland valleys or lower river terrace	LL, LC, CC	q h f e
Aquents Aquepts	Alluvium	Inaldn malley and swamps; river deltas and flood plains, mangrove swamps	LL, SL, LC, LLR, SLR, CC	q, other modifiers vary widely

Source: Juo and Kang, (1979)
1 For details see below.

Textural Types
S = Sandy, > 85 percent sand.
L = Loamy texture, < 35 percent clay.
C = Clayey texture, < 35 percent clay.
R = Quartz or ironstone gravels or other hard, root-restricting layer present in 20-50 cm depth.

Condition Modifiers (0-50 cm)
e = Low effective CEC (< 4 meq/100 g of soil) between 0-50 cm depth.
h = Acidic exchangeable Al saturation (10-45 percent), pH (H_2O) less than 5.5.
a = Al toxic, exchangeable Al saturation greater than 45 percent.
k = K deficient, exchangeable K less than 0.15 meq/100 g of soil, less than weatherable minerals in silt and sand fraction,
i = High P fixation, standard P requirement at 0.2 ppm in solution greater than 350 ug/g.
m = Mn toxicity, soil pH below 5.0 for soils derived from high Mn-containing parent rocks.
t = Secondary and micronutrient deficiencies (i.e., Mg, S, Zn).
w = Low available water reserve (i.e. less than 50 mm).
d = Dry, Ustic, or Xeric environment, soil remains dry for more than 60 consecutive days per year within 20-60 cm depth.
r = High erosion hazard, unsuitable for large-scale food crop farming
q = Wet soil moisture regime. Profile is saturated during most of the growing season.
f = Fe toxicity in wetland rice.
* = Soil fertility constraints resulting from continuous cropping with moderate to high rates of chemical fertilization and inadequate soil management.

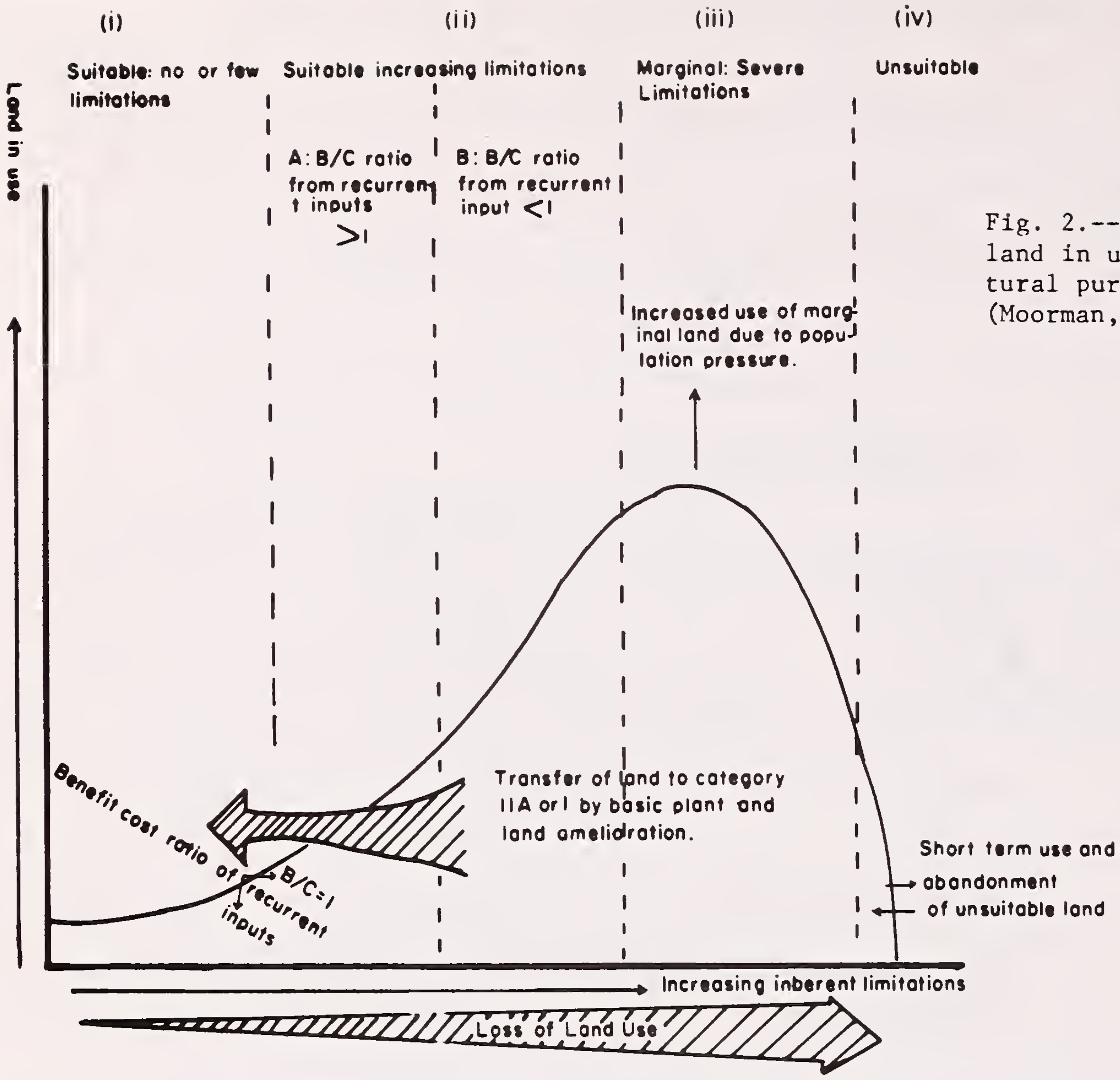


Fig. 2.--Model of the relation of land in use for a specific agricultural purpose, and land quality. (Moorman, 1975).

Figure 2 is a graphic model relating land use for specific agricultural purposes with land quality. Alternative management strategies under test consist of various environmental or resource manipulations and input mixes with their attendant risks and effects on environmental quality, cost benefit ratios and overall human welfare in relation to the different capability classes. Reliable simulation models enhance extrapolation of results to areas with similar features when studies are based on the monitoring of changes and consequences of management practices on benchmark sites established in well defined ecosystems with different soils, topographic, climatic and land use features.

The systems approach to the improvement of farming systems or cropping systems in the International Agricultural Research Centers and elsewhere calls for detailed study of existing systems and the farmers socio-economic environment so as to enhance our understanding them repairing or improving them in addition to constructing new ones. Thus farming systems research of this type culminates in development of alternative farm management plans which may be generated through of (i) modification of a farmer's agroecosystem management plan, (ii) synthesis of agroecosystem management plan based on agroecosystem design and management principles and (iii) mimicking analogous natural plant systems (Hart, 1978). The flow of materials and energy through an agroecosystem with a crop subsystems are shown in Figure 3.

USE OF SPECIAL AREAS FOR MULTIPLE USE RESEARCH

Since agricultural systems are by and large site specific, multiple use research stations are best located in areas that are representative of well defined ecosystems, regions or benchmark sites. Moreover, in our attempts to identify land best suited for forestry, wild life, agricultural production, irrigation and so on either suitable sites are selected on the basis of existing knowledge about sites most suited for the different alternative uses or through studies of outcome of various management systems on different landscapes. Since land is rarely uniform over extensive areas and it is not always possible to carry out hydrologic studies and monitor movement of materials in and out of an ecosystem on the flat, a sample area suitable for the study is always selected. For stdies of erosion and hydrology a watershed forms a suitable natural unit with well defined boundaries.

Watershed studies facilitate studies in hydrology, erosion, leaching, pollution and various processes associated with different land use practices. Likens and Bormann (1971) illustrate nutrient-hydrologic interactions with studies of

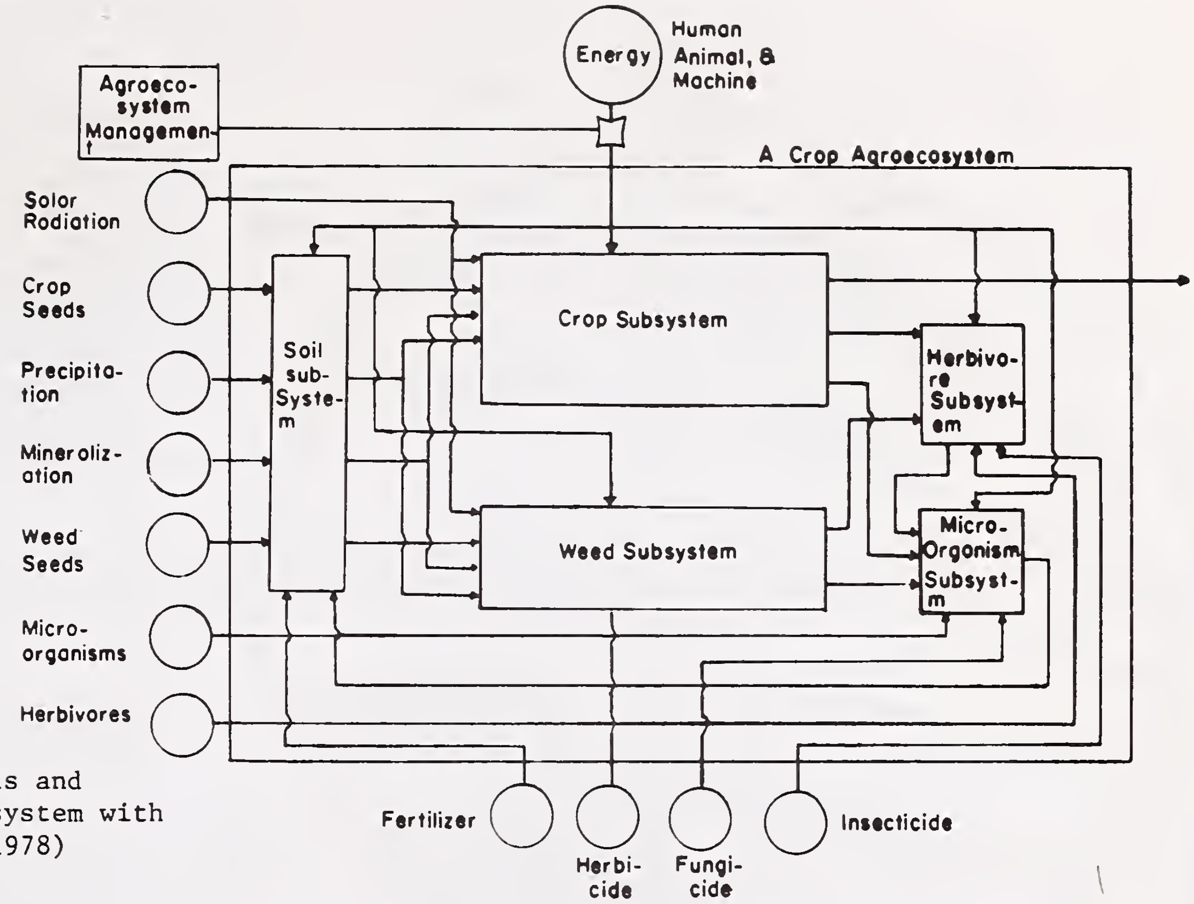


Fig. 3.-- Flow of materials and energy through an agroecosystem with a crop subsystem. (Hart, 1978)

small watershed ecosystems of Hubbard Brook Experimental Forest, Harrold, Schwab and Bondurant (1976) report uses of watersheds, catchments and reservior in agricultural and forest hydrology studies and guidelines for watershed management are given in FAO (1977). An integrated watershed management project and associated technology evaluation at various levels of technology based on the unit farm approach at IITA has already been referred to above (Table 3).

A watershed has also been found most suitable for evaluation of effects of different intensities of mechanized forest clearing techniques and subsequent cropping practices on crop yield, runoff and soil fertility (Figures 4 and Table 6).

TABLE 6: Deforestation and tillage systems in relation to runoff in a watershed management experiment at IITA, Ibadan, Nigeria

	Treatment	Runoff (mm)	Soil loss (t/ha)	Grain yield maize (t/ha)
	Traditional	2.6	0.01	0.5a[1]
Manual clearing - no tillage	MC - NT	15.5	0.4	1.6b
Manual clearing - conventional tillage	MC - CT	54.3	4.6	1.6b
Crawler Tractor shear blade - no tillage	SB - NT	85.7	3.8	2.0b
Crawler Tractor (tree pusher/root rake - no tillage)	TP - NT	153.1	15.4	1.4b
Crawler Tractor (tree pusher/root rake + conventional tillage).	TP - CT	250.3	19.6	1.8b

Source: IITA Research Highlights, 1979

1 Figures followed by the same letter arenot significantly different at 5%

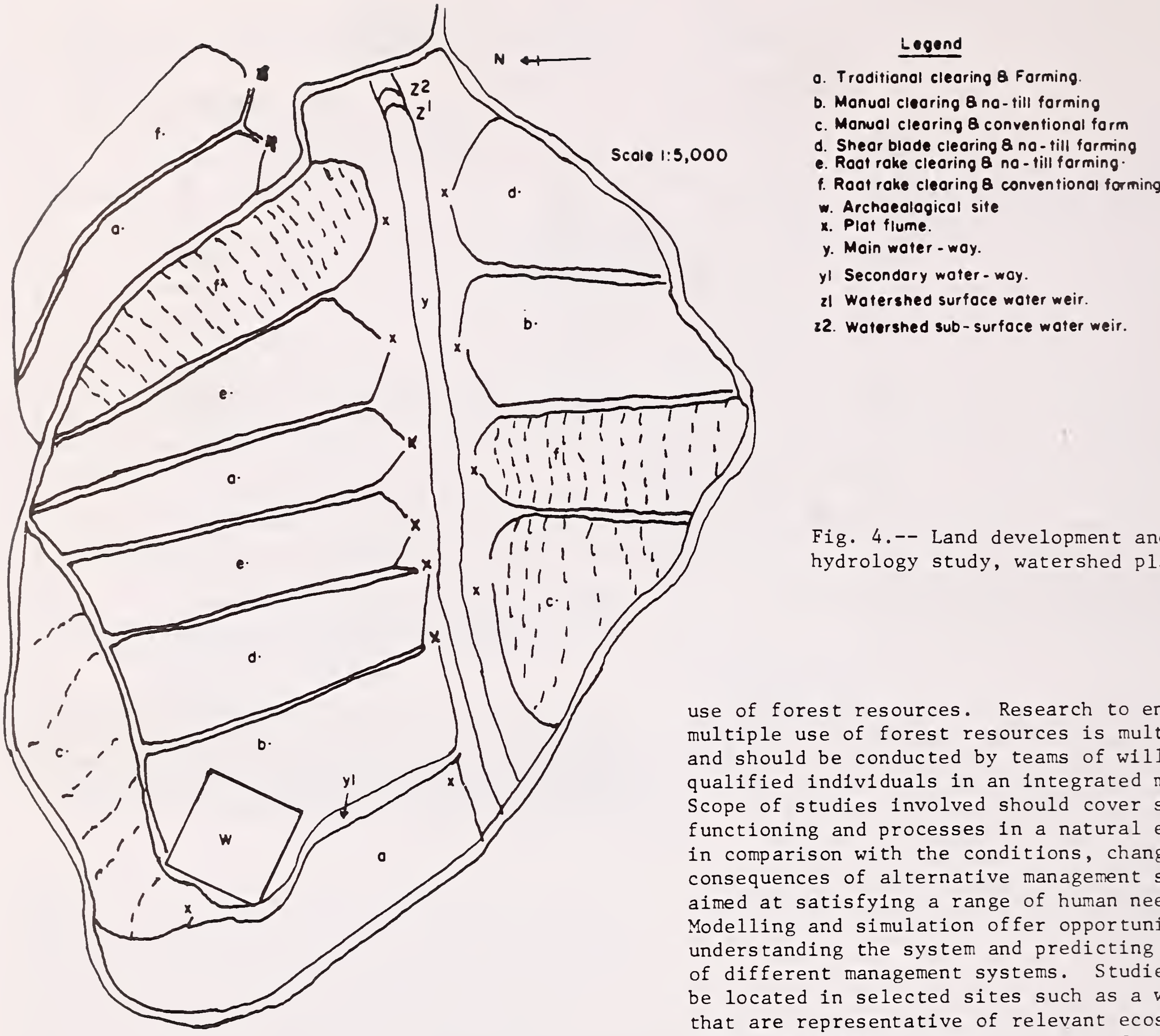


Fig. 4.-- Land development and hydrology study, watershed plan.

These watershed studies involve interdisciplinary teams and initial forest inventory necessitated collaboration with institutions outside IITA in addition to participation of a farm machinery company that used the project to demonstrate the capabilities of its farm machinery.

SUMMARY AND CONCLUSIONS

The tropical African environment is reviewed, and it is emphasized that rapid population growth, clearing of more land to grow more food, fibre, fuelwood, timber and other miscellaneous products on a continuing basis; rapid rate of urbanization and infrastructural development activities related to transportation, tourism, irrigation, mining etc. have all contributed to the existing serious pressures on limited land resources. These and the complex socio-economic problems of African countries of different political and cultural backgrounds must be taken into account in establishing the need and strategies for achieving multiple use of forest resources. Research to enhance multiple use of forest resources is multidisciplinary and should be conducted by teams of willing and qualified individuals in an integrated manner. Scope of studies involved should cover structure, functioning and processes in a natural ecosystem in comparison with the conditions, changes and consequences of alternative management strategies aimed at satisfying a range of human needs. Modelling and simulation offer opportunities for understanding the system and predicting effects of different management systems. Studies are to be located in selected sites such as a watershed that are representative of relevant ecosystems or benchmark areas or zones within the forest zone of concern.

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DEVELOPPEMENT DES SYSTEMES D'USAGE MULTIPLE TROPICALES GRACE A DES RECHERCHES EN AFRIQUE

L'environnement tropical africain est étudié, et il est clairement montré qu'une croissance rapide de la population, le défrichement de plus de terre pour produire plus de nourriture, de fibre, de bois de chauffage, de bois de construction et de divers produits et cela à un rythme continu; le taux rapide d'urbanisation et des activités de développement infrastructurel liées au transport, au tourisme, à l'irrigation, à l'exploitation des mines, etc., ont tous contribué aux sérieuses pressions actuelles sur les ressources limitées de la terre. Ces problèmes ainsi que les problèmes socio-économiques complexes de pays africains de diverses formations politiques et culturelles doivent toujours rester présents à l'esprit quand on établit le besoin et les stratégies pour réussir l'usage multiple des ressources de la forêt. Les recherches pour améliorer l'usage multiple des ressources de la forêt sont multi-disciplinaires et doivent se faire de façon intégrée par des équipes d'individus qualifiés et de bonne volonté. Le champ des recherches doit couvrir la structure, le fonctionnement, et les processus d'un écosystème naturel comparés aux conditions, changements et conséquences de différentes stratégies de gestion destinées à satisfaire à une gamme de besoins humains. L'emploi de modèles et la simulation aident à la compréhension du système, et permettent de prévoir les résultats des différents systèmes de gestion. Les recherches doivent se faire dans des sites choisis, ligne de partage des eaux, par exemple, qui sont représentatifs des écosystèmes étudiés, ou dans des zones de repère à l'intérieur de la forêt en question.

ENTWICKLUNG VON VIELFALTIGER NUTZUNGSANWENDUNG FUR TROPISCHE WALDER DURCH FORSCHUNG IN AFRIKA

Es wird über die tropischen, afrikanischen Umweltverhältnisse berichtet und betont, dass folgende Entwicklungen für den schwerwiegenden Druck auf Nutzung der beschränkten Landeskulturprodukte verantwortlich waren: schneller Bevölkerungszuwachs, Vernichtung von mehr Wäldern, um kontinuierlich mehr Nahrung, Chemieholz, Brennholz, Nutzholz und verschiedene andere Produkte zu erhalten; schneller Wuchs der Verstädterung, und behördliche Entwicklungsmassnahmen, die mit Verkehrseinrichtungen, Fremdenverkehr, Bewässerung, Bergwerkstätigkeit zu tun hatten. Diese und die komplexhaften sozioökonomischen Probleme der afrikanischen Staaten mit verschiedenem politischem und kulturellem Hintergrund müssen in Betracht gezogen werden, wenn die Notwendigkeit erkannt und die Strategie für das Erreichen einer vielseitigen Nutzung der Forsten geplant werden soll. Die Forschung, vielseitige Forstnutzung zu verbessern, muss viele Disziplinen umfassen und sollte von einer Gruppe von bereitwilligen und qualifizierten Personen durchgeführt werden, die geneigt sind, die Forschungszweige zu integrieren. Die Untersuchungen sollten umfassen: die Struktur, Funktion und Prozesse der natürlichen ökologischen Systeme im Vergleich mit dem gegebenen Zustand, Veränderungen und Folgen von verschiedenen Bewirtschaftungsstrategien, deren Ziel es ist, eine Reihe von Nutzbarmachungen zu ermöglichen. Untersuchungen sollten in ausgesuchten Gebieten ausgeführt werden, zum Beispiel in einem Wassereinzugsgebiet, das ein wichtiges ökologisches System repräsentiert, oder in einem für grössere Gebiete typischen Standort, oder Zonen innerhalb von Forstzonen, die von Interesse sind.

EL EMPLEO DE USO MULTIPLE EN EL DESARROLLO DE MANEJO DE SELVAS TROPICALES, MEDIANTE INVESTIGACIONES EN AFRICA

Se describe brevemente el ambiente africano tropical, y se atribuye a los siguientes factores las serias presiones existentes sobre los recursos limitados de tierra: 1) el aumento rápido de la población, el desmonte de los terrenos para cultivar cosechas que rindan fibra, leña, madera, y varios otros productos en una base continua, y 2) el grado rápido de urbanización y el desarrollo infra-estructural, actividades pertinentes al transporte, turismo, irrigación, minería, etc. Estos y los problemas complejos socio-económicos de los países africanos de diferentes fondos culturales y políticos deben ser considerados al establecer las necesidades y estrategias para ejecutar el aprovecho múltiple de los recursos forestales. La investigación para incrementar el aprovechamiento múltiple de los recursos forestales es multidisciplinaria y debería ser conducida en una manera integrada por grupos de individuos interesados y competentes. El alcance de los estudios involucrados debería de cubrir estructura, funciones y procedimientos en un ecosistema natural en comparación con las condiciones, los cambios y las consecuencias de estrategias de aprovechamientos alternativos dirigidos a satisfacer varias necesidades humanas. El uso de modelos y la simulación ofrecen oportunidades para comprender el sistema y para predecir los efectos de diferentes sistemas de aprovechamiento. Los estudios se ubicarán en sitios escogidos, tales como una cuenca hidrológica, que son representantes de ecosistemas pertinentes o áreas de referencia o zonas dentro de la zona forestal de interés.

Developing Multiple-Use Silvicultural Practices for Forests of Arid Regions[1]

W.A.Kermani[2]

Abstract.-- Water scarcity, land hunger, rising population, mounting food demands, present a challange to Pakistan's arid zone, necessitating development of agro-forestry practices. Acacia nilotica and Eucalyptus camaldulensis were raised under numerous replications with cotton, wheat, sesamum, sorghum. Such multiple-use of land indicates that Eucalypt-cotton combination is best for production and profits.

INTRODUCTION

The southern most province of Pakistan namely Sind, with which this paper deals, constitutes that part of earth's land surface which is universally recognised as arid zone (Figure 1). The criterion of arid zone as conceived in this paper is the area that receives less than 300 mm. (12") of rainfall per year and where during the course of an year the potential water losses through evaporation and transpiration exceed precipitation; while the temperatures during long summer months rise upto 120 F^{o} (49 C^{o}) and the winter temperatures hover round 65 F^{o} (18 C^{o}) (Figure-2).

The ecological set up in Sind is dominated by the water regime of the river rather than the general climate. The meandering course of Indus river within Sind is 580 miles long covering the distance of 380 miles as crow flies. The river flows on a ridge and is annually inundated. The waters of Indus are contained by the artificial embankments constructed throughout the length on either side, so that about 20 miles between two embankments become the flood plain. The land across these embankments is irrigated through a net work of canals taking off from the three barrages built on it.

The riverain forests within the flood plain of the river extending over 595,807 acres (241,123 ha) consist of four main species namely, Acacia arabica (Syn. Acacia nilotica) Prosopis spicigera, Poplus euphratica, Tamarix spp.

The land beyond flood plains is irrigated by canals. In this tract, 150,000 acres have been allotted to the Forest Deprtment for raising irrigated plantations. These forests, at present, carry scrub growth and are being converted into irrigated forest plantations.

The forestry practices in these two types of forests differ because in the flood plains the river inundation water is directly available to plants for about three months in a year while in the irrigated plantations the scarce water has to be given in predetermined quantities to keep the crops flourishing. The inundation water in the flood plains of the river keeps the forest crop submerged sometime upto a height of 3-6 feet, while in the irrigated plantations the net work of irrigation system serves the crops with a delta of 2-3 feet.

With water scarcity, rising population, demand for more land for agricultural use, and mounting demands for food crops, the Forest administration is obliged to make utmost use of land as well as water and maximise production. The conflict between agricultural demands and forestry practices has to be avoided. Nonetheless forests are needed by the people for the use of their wood products. So as to strike a healthy balance, it has been necessary to combine agricultural practices with forestry management in the irrigated forest plantation areas particularly, and in the riverain forests generally. How these multiple use research techniques have been evolved and the practices standardised in the course of about a decade is set forth in this paper.

PROBLEM

Any land to be brought under irrigated forest plantation has to be initially developed, levelled, irrigation system laid out and then the planting is to be done. The initial expenditure required on the land development work alone is Rs.1000/- per acre (US $ 100/-). Thus the total expenditure required for land development spread over 150,000 acres works out to Rs. 150 million (US $ 15 million). In a developing country such high costs on a low priority item like afforestation are almost

[1] Invited paper presented at the IUFRO/ MAB Conference: Research on Multiple-Use of Forest Resources, Flagstaff, Arizona, May 18-25, 1980.

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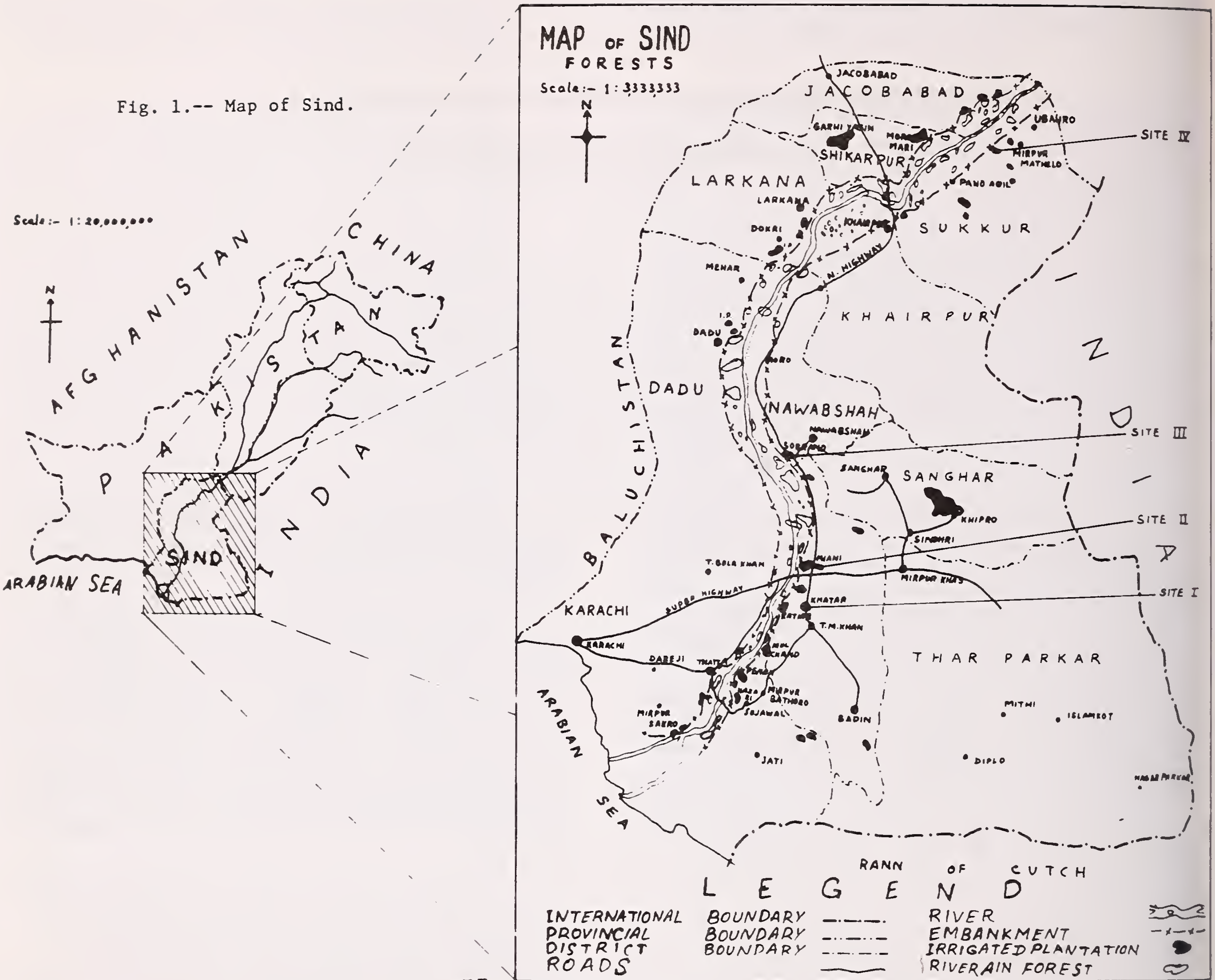
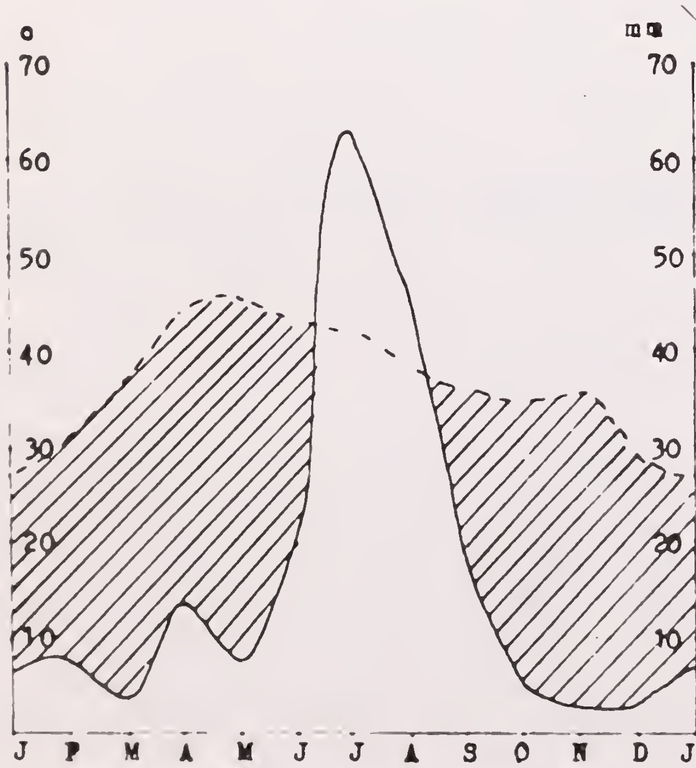
Fig. 1.-- Map of Sind.





unbearable for the public exchequer. Therefore in order to raise these plantations, the method of agro-forestry system was adopted. A combination of agricultural practices with forestry, compensates the costs of such operations while at the same time it increases productivity from a given land area. The attention of the foresters was engaged to the problem of how best they can go about in evolving a system whereby multiple use of land could yield highest economic benefits.

The system is not new as it has been prevalent in many countries of south Asia such as Burma, Bangla Desh and India. In these countries agro-forestry system commonly known as 'Taungya' has been practised since 1862. In this system, confined

Fig. 2.-- Mean annual rainfall and temperature 1933-1977, Hyderabad Station.

——— Rainfall, in mm
------- Temperature, °C
/////// Dry period

to rainfed forests only, shifting cultivation is practised but the tree crops are raised after the raising of agricultural crop has ceased, and thus the period for which the area is under cultivation is lost to tree growth. The system adopted in Sind is somewhat different because in this system the forestry crops are raised simultaneously with the agricultural crops after proper land development, and the area is provided artificial canal irrigation.

EXPERIMENT

The experiment which was laid out was to determine the best combination of agro-forestry crops in the irrigated forest areas.

Site location

There were four sites selected in different ecological zones. The selections were as follows:-

i) Khathar Plantation (Hyderabad district)

ii) Kathri Plantation (Hyderabad district)

iii) Pai Plantation (Nawabshah district)

iv) Mirpur Mathelo Plantation (Sukkur district).

Tree species

The tree species that were selected for planting in these areas were:-

i) Acacia arabica Syn. Acacia nilotica

ii) Eucalyptus camaldulensis.

Agriculture crops

The following agricultural crops were raised with one control:-

i) Cotton

ii) Wheat

iii) Sesamum

iv) Sorghum

v) Control

Irrigation

The irrigation water dosage was decided on the basis of the normal irrigation dosage used for particular varieties of agricultural crops which was as follows:-

	Crop	Total depth of irrigation in inches.	No. of irrigations.
i)	Cotton	36"	12
ii)	Wheat	18"	6
iii)	Sesamum	19"	3
iv)	Sorghum	18"	6
v)	Control	36"	12

Note: Each irrigation provides a delta of 3 inches of water.

Replications

It was decided to select the most easily understandable design of experiment and therefore random block design was chosen with six replications. Thus the number of sub-plots at each site was as follows:-

i) Acacia arabica	-	30
ii) Eucalyptus camaldulensis		30

Area of each sub-plot	-	2.0 acres
Total area under study 60 x 4 x 2 =		480.0 acres
Spacing	i. Acacia arabica -	20'x 6'
	ii.E.camaldulensis-	20'x 6'
Number of plants per acre.	i. Acacia arabica -	363
	ii.E.camaldulensis-	363
Total number of plants at each location.	i. Acacia arabica -	21,780
	ii.E.camaldulensis-	21,780
Total plants in the entire study.	i. Acacia arabica -	87,120
	ii.E.camaldulensis-	87,120
Establishment of experiment.		March 1974

The study has been orientated at four different locations and an area of 60 acres (24.36 ha.) was developed at each location,levelled and irrigation system laid out. The saplings were planted in lines 20 feet apart. In these tree lines, planting distance was kept as 6 feet. These tree lines were kept free of all growth in 3 feet width. The intervening space of 17 feet between the tree lines was used for raising of agricultural crops. One year old seedlings of Acacia arabica and Eucalyptus camaldulensis were planted. The height of the seedlings at the time of planting was 1½ to 2 feet. Pre-prescribed and pre-determined irrigation and cultural treatments were provided to each of the agricultural crop and control area.Fertilizer was, however, not given in the control plots. The record of height of tree crop was obtained after each growing season (December) while at the end of three years, height and girth were finally recorded. (Figs. 3 and 4)

After three years it was not possible to raise the agricultural crop successfully owing to the heavy shade of the trees.

Observations

Height and girth of Acacia arabica and Eucalyptus camaldulensis on four different sites was measured and analysed as shown in Table 1. Agricultural crop production and its value is detailed in Table 2.

The volume of wood produced by the two tree species in combination with the four agricultural crops is shown in Table 3. Net profit per acre per year is summarized in Table 4.

Fig. 3.-- Acacia arabica with cotton in the third year. Kathri Site II.

Fig. 4.-- Eucalyptus camaldulensis with cotton in the third year. Kathri Site II.

Table 1.--Growth after 3 years for Acacia arabica and Eucalyptus camaldulensis grown with agri-crops

Crop	Acacia		Eucalyptus	
	Height	Girth	Height	Girth
	feet	inches	feet	inches
Cotton	12.2	10.4	28.8	11.9
Wheat	10.8	8.7	27.3	10.9
Sesamum	10.0	8.4	26.4	10.3
Sorghum	9.7	8.1	25.7	9.5
Control	8.9	7.4	22.3	8.3

Table 3.--Volume of wood per acre with agri-crops

Crop	Acacia	Eucalyptus
	ft^3	ft^3
Cotton	680.5	764.4
Wheat	544.4	764.4
Sesamum	408.4	502.9
Sorghum	453.8	502.9
Control	408.4	456.3

Table 2.--Yield of agri-crop per acre per year with Acacia arabica and Eucalyptus camaldulensis, 1976-1978 average

Crop	Price per Maund[1]	With Acacia		With Eucalyptus	
		Yield	Total income	Yield	Total income
	Rs	Md	Rs	Md	Rs
Cotton	124	11.2	1,389	11.9	1,469
Wheat	45	16.4	738	18.2	818
Sesamum	150	3.6	536	4.4	656
Sorghum	40	7.8	311	8.9	356

[1] 1 Maund = 37.3 kg, 82.3 pounds
10 Rupees = 1 U.S. dollar

Table 4.--Net profit (Rs) per acre per year from agri-crops grown with Acacia arabica and Eucalyptus camaldulensis

Crop	Expenditure (sowing to harvesting)	Acacia		Eucalyptus		Difference per acre
		Gross income	Net profit	Gross income	Net profit	
Cotton	400	1,389	988	1,469	1,069	81
Wheat	300	738	438	818	516	78
Sesamum	250	536	284	656	406	122
Sorghum	100	311	211	356	256	45

Results

From the data obtained from each study at four different locations it has been established that:-

i) Although an exotic, E. camaldulensis has put on more volume under all treatments than the indigenous Acacia.

ii) The yield of agriculture crop is higher with Eucalyptus camaldulensis as compared to that with Acacia arabica.

iii) Under E. camaldulensis, the yield of agricultural crops was in the following descending order:-

Cotton, Wheat, Sesamum and Sorghum.

iv) Growth of tree crop is best with cotton followed by wheat, sesamum, sorghum, while it is lowest under control. The factors determining variation in tree growth are obviously soil working, use of fertilizer, and intensity of irrigation.

While the objective was mainly to find the best combination of agro-forestry crops to yield maximum production benefits, the difference of agricultural crop yield was measured in terms of monetary returns and of the forestry crops in terms of growth. The results obtained show that the yield of agricultural crops raised in combination with Eucalypts was more favourable than those raised with Acacias and Eucalypts-cotton combination was best for higher yield of wood as well as greater monetary returns from agricultural crop.

It has also been confirmed by statistical analysis that height and girth of both Acacia arabica and Eucalyptus camaldulensis at all four sites was significantly higher (0.01 level) with cotton than with the other crops or the control.

DISCUSSION

The data obtained and analysed indicate that raising of agriculture crop in combination with tree crop is beneficial for forestry production and adds to the profit.

It is imperative to level the land for raising forestry/agricultural crops under artificial irrigation. The levelling operations are relatively expensive. Besides, the wildlands have to receive such other treatments which may make them fit for cultivation. Broadly, the operations could be grouped as follows:-

i)	Scrub clearange including uprooting of stumps.	Rs. 200
ii)	Levelling	Rs. 600
iii)	Layout of irrigation system.	Rs. 200
		Total Rs.1000

This expenditure is offset by income from agricultural crops and the extra agricultural production still remains the dividend. During the three years period that agricultural cultivation is done, the forest tree crop not only receives irrigation water but is also benefited from the fertilizer and cultural operations such as weeding, hoeing etc. In this manner the initial cost of tree crop formation is entirely saved while growth benefits accrue in addition.

The results indicate that while in the control plot the volume at the end of three years period in the case of Eucalyptus camaldulensis was 456.2 cft, it rose to 502.8 cft in the case of Sorghum and 764.5 cft with cotton.

Similarly in the case of Acacia arabica while in control plot it was 409.0 cft, it rose to 454 cft with Sesamum and 680 cft with cotton.

CONCLUSION

From the foregoing results and discussions on the study, it can be concluded that the agro-forestry practices are distinctly advantageous than the formerly existing system of planting forestry crops only.

The multiple-use of forest lands combining agri-cum-forestry practices have shown that such blending maximises productivity resulting in tangible and intangible benefits which can be summarised:-

i) Maximum use of valuable water resources is made.

ii) Maximum productivity from the land is obtained.

iii) National effort towards agricultural productivity is significantly supplemented.

iv) Supply of essential commodities of food and wood products is ensured.

v) Since the agricultural crops use fertilizers, the soils are enriched.

vi) Better environment and habitat are created for conservation of wildlife particularly the partridge.

vii) Micro-climate is benefically affected and improved.

viii) Forestry practices become self supporting in initial stages and financial burden on exchequer is significantly reduced.

ix) Labour intensive agro-forestry system generates more employment opportunities for the rural population.

SERICULTURE

Limited time and space permit only a fleeting reference to be made about the recent introduction of sericulture, in two suitably selected forests of this arid region, as yet another tool of multiple land-use. Although the experiments are in their infancy yet some encouraging results are noteworthy. The local foresters have had the experience of growing mulberry, Morus alba, as a

shade bearer with the light demander Dalbergia sisso, for timber/fuelwood harvesting. With the knowledge of mulberry cultivation, it was merely a matter of growing such varieties which could produce heavier foilage and larger leaf surface for providing plentiful, healthy feed to silkworms. The desired expertise was obtained from China and Japan. The Chinese varieties of mulberry known as Ching Sung and Husung and Japanese varieties of Roso; Akame; Shirome; Shinichinose were imported. These varieties were raised mixed with exotic Australian Poplars and Eucalypts, spaced at 15 ft x 15 ft and interplanted with mulberry placed at 5 ft. Roso mulberry variety of Japan has shown best results followed by Chinese Ching Sung.

The experience gained in the last three years could be broadly outlined as follows:

1) The exotic mulberry bushes are flourishing and the Roso variety yields an average of 3 kg of leaves per bush (4650 kg per acre) from February through April when the leaves are needed to feed silkworms.

2) The leaf production of 4650 kg on an acre is adequate feed for the larvae hatching from 112 gm of eggs; 1 gm of eggs produce 1666 larvae.

3) Two crops of silk cocoons are produced in 3 months period, staggerin g each lot of egg-hatching by about 2 weeks.

4) One generation of silkworm from 28 gm. of eggs yield 6 kg. of silkyarn valued at Rs.350/- per kg. giving a gross income of Rs.2100/- and net income of Rs.1500/- that is Rs.6000/- per acre.

5) The Departmental functionaries have hatched 1120 grams of eggs producing 240 kg of silkyarn in 3 years period ending April 1979 with a working expenditure Of Rs.24,000/- leaving a net revenue of Rs.60,000/- .

6) The families of forest labourers were also taught silkworm rearing who used 8400 gms of eggs distributed in 300 families during the same 3 years period.

7) The womenfolk and their children enjoy silkworm rearing which is slowly becoming a sort of cottage industry as the labourers earn and supplement their income for a quarter of each year. This is affording an added attraction to the forest labourers to settle near the forests rather than drifting away.

GENERAL

The riverain forest management, devoted chiefly to production of timber, pitprops and fuelwood, yields considerable revenue, appreciably exceeding expenditure (Revenue Rs.24,840,000 Expenditure: Rs 18,680,000). The standardisation of agro-forestry practices in the 'inland forest' areas has added a new dimension. These financial results have convinced the Government that forestry could indeed be a self supporting proposition and therefore the Forestry Department has been allowed to work independently as a "self-financing" unit, free to invest rational part of its profits for reforestation/afforestation/management and turning over the surplus revenues to the exchequer. The exclusive 'self financing system', so strengthened by agro-forestry and sericulture practices, has become a landmark in the history of arid zone forestry management in this region. The applied research on multiple-use of forest lands, essentially projected in easily understandable and demonstrable manner, has had the desired effect to show that forestry is neither in competition nor in conflict with agriculture while the productivity from forest lands could be maximised even with the constraints that accompany arid land forestry. The economic support so rendered to the rural populatin has, in no small measure, aroused consciousness which brings willing cooperation and participation of the people.

DEVELOPPEMENT DES PRATIQUES DE SYLVICULTURE DIVERSIFIEES POUR LES FORETS DES REGIONS ARIDES

Des résultats et discussions présentés dans cette étude, il peut être conclu que les pratiques de sylviculture sont nettement plus avantageux que le système employé auparavant de planter seulement des arbres.

L'usage multiple des terres de forêt combinent les pratiques d'agriculture et de sylviculture a montré qu'une telle combinaison produit une productivité maximale avec pour résultats des avantages tangibles et intangibles qui peuvent se résumer comme suit:

i) Il est fait un usage maximal des ressources en eau précieuses.

ii) Une productivité maximale est tirée de la terre.

iii) L'effort national pour la productivité agricole est considérablement augmenté.

iv) La production des vivres et du bois est assurée.

v) Comme les cultures agricoles se servent d'engrais, les sols sont enrichis.

vi) Un environnement et un habitat meilleurs sont créés pour la conservation du gibier et surtout pour les perdrix.

vii) Le microclimat est affecté avantageusement et est amélioré.

viii) Les pratiques forestières subviennent à leurs propres besoins financiers durant les premiers stades et les charges de l'état sont considérablement réduites.

ix) Le système d'agro-sylviculture exige beaucoup de main d'oeuvre et crée plus d'emplois pour la population rurale.

EL DESARROLLA DE PRACTICAS SILVICULTURALES DE USO MULTIPLE PARA LOS BOSQUES DE REGIONES ARIDAS

De los resultados precedentes y las discusiones del estudio, se puede concluir que las prácticas agro-dasonómicas son definitivamente más ventajosas que el sistema que existía en tiempos pasados de sembrar solamente cosechas forestales.

El manejo del aprovecho múltiple de terrenos forestales combinando prácticas agro-dasonómicas ha indicado que esta combinación maximiza la producción, resultando en beneficios tangibles y intangibles, los cuales pueden ser resumidos:

(1) Se aprovecha al máximo el recurso valioso de agua.

(2) Se obtiene una productividad máxima de la tierra.

(3) El esfuerzo nacional hacia la alta producción agrícola es suplementado significativamente.

(4) Se asegura la provisión de géneros de alimento y productos de madera.

(5) Puesto que las cosechas agrícolas usan fertilizantes, las tierras se han enriquecido.

(6) Un mejor ambiente y habitat son creados para la conservación de la fauna silvestre, particularmente la perdiz.

(7) El microclima es afectado beneficialmente, y es mejorado.

(8) Las prácticas forestales llegan a ser autofinanciadas en grados iniciales, y la carga monetaria del fisco es significamente reducida.

(9) El sistema intenso de agro-dasonomía genera más oportunidades de empleo para la población rural.

ENTWICKLUNG VON MASSNAHMEN FUR VIELFALTIGE FORSTLICHE NUTZUNG IN WALDERN DER ARIDEN ZONEN

Auf Grund der Resultate und Beurteilung der Untersuchung kann der Schluss gezogen werden. dass die Agrar- Forstwirtschaft einen wirklichen Vorteil über die frühere Methode der alleinigen Baumpflanzung hat.

Die vielseitige Nutzung von Wäldern, die Landwirtschaft mit Forstwirtschaft verbindet, hat gezeigt, dass diese Verbindung Produktivität zu maximaler Höhe bringt, und dies bewirkt messbare und unmessbare Gewinne, die zusammengefasst werden können:

i) Maximale Nutzung von Wasser ist ermöglicht.

ii) Maximale Produktivität des Bodens ist erreicht.

iii) Dem nationalen Streben nach landwirtschaftlicher Produktion ist erheblich geholfen.

iv) Die Versorgung von notwendiger Nahrung und von Holzprodukten ist sichergestellt.

v) Da landwirtschaftliche Anbauung Düngung benötigt, werden die Böden bereichert.

vi) Bessere Umwelt- wowie Lebensbedingung ist für die Erhaltung der wilden Tiere geschaffen, besonders für das Rebhuhn.

vii) Das Mikro-Klima ist günstig beeinflusst und verbessert.

viii) Forstwirtschaftliche Massnahmen bedürfen keinerlei Hilfe von aussen während des Anfangsstadiums, und die finanzielle Last für die Staatskasse ist beträchtlich verringert.

ix) Das arbeitsintensive Agrar-Forstsystem schafft mehr Arbeitsplätze für die ländliche Bevölkerung.

Predicting Multiple Benefits from Silviculture[1]

Stephen G. Boyce[2]

Abstract.--This paper describes an orderly way to plan, control, and direct the transformation of forests from one state to another. This ordered transformation provides time-varying variables, namely, the temporal and spatial dispersion of habitats, that can be used to predict the potential for any and all forest benefits singly and in combinations.

INTRODUCTION

We feel comfortable predicting when the sun will rise tomorrow, the phase of the moon 4 days or 400 days from today, and when Mars will rise and set. These predictions are projections of relationships scheduled by orderly changes in the universe.

Large numbers of variables are changing simultaneously. Yet, predictions for future states of the solar system can be made from values for a relatively few variables. These variables, such as position on the earth, date and time, can be used with some tables to project the relative position of many bodies in the solar system.

Forest ecosystems are enormously complex because, like the solar system, they have large numbers of variables changing simultaneously. In this paper I propose ways to systematically use two control variables, rates of timber harvest and sizes of openings formed by timber harvest, to order the ecosystem dynamics of forests. This orderly way to transform the forest from one state of organization to another provides predictable, time-varying variables, namely, the temporal and spatial dispersion of habitats that can be used to project the potential for any and all forest benefits singly and in combinations.

This method is useful because values for only a few variables are needed to predict over time multiple benefits for alternative cultural actions.

THE PROBLEM OF PROLIFERATING COMPLEXITY

The primary difficulty in predicting multiple benefits from silviculture is the complexity of ecosystem dynamics created by many variables changing simultaneously. This complexity limits our ability to predict multiple benefits in relation to silviculture. An example will illustrate the significance of the problem.

Assume a forest manager wants to provide some combination of timber, water, wildlife, recreation, and wilderness experiences. For one benefit the variety of the prediction and of the decision process is 2^1, a choice of large or small for one of the benefits. For the five benefits the variety of the decision is $2^5 = 32$ alternatives.

When the manager takes this question to his staff the complexity proliferates. The timber specialist says he cannot deal with the question unless he specifies the amounts of sawlogs and pulpwood logs by hardwood and softwood species. The wildlife specialist says that he must specify nongame birds, deer, squirrel, and turkey. The recreation specialist describes developed and undeveloped recreation areas. The wilderness manager must deal with back country experiences as well as visual experiences from highways. The watershed specialist adds peak flows and normal flows. Suddenly the variety is $2^{14} = 16,384$ alternatives. This is a large number but it represents only a portion of the variety, which is a measure of the complexity for decisions and predictions.

The complete variety for the management process includes the benefits desired and the cultural actions required to produce each benefit. From management, we learn that control can be obtained only if the variety of the controller is at least as great as the variety to be controlled (Beer 1966). Thus, we must predict the alternatives not only as the combination of benefits desired, but also as the combination of silvicultural

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[1]Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, Flagstaff, Arizona, May 18-23, 1980.

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actions required to produce the benefits. The variety is increased to the number of ways of combining 2^{14} combinations of benefits with 2^{14} combinations of silvicultural actions. The number of combinations is beyond the comprehension and control of any management team.

In practice, complexity is never permitted to proliferate to these large numbers. Thus, the multiple-benefit concept is constrained by complexity. Variety for predictions is always limited to values of 2 to 5 and very rarely to those as large as 8, which are the limits for effective decision and control in most human organizations. We select the most "important" variables and use them in some kind of analytic method that will reduce variety to a choice of one of two primary benefits. Increasing demands to harmonize cultural actions for the production of a wide array of biologically possible benefits is forcing forest managers to find a new way to contain proliferating variety.

THE NEW DIRECTION

The new direction is to systematically provide multiple benefits rather than a single benefit or a two- or three-combination goal. This is achieved by bringing about an orderly change in the states of organization of the forest, namely, the dynamic dispersion of stands of age and area classes and forest types. The biological processes that transform stands from one structure to another is used to absorb proliferating variety that is created by demands from increasing numbers of special interest groups. The complexity of silviculture and management decisions is constrained because actions are directed toward a single goal, a state of organization, and because only two variables, rates of harvest and size of openings formed, are required to direct an orderly change in the states of organization of the forests. From this orderly change any and all benefits, singly and in combination, can be projected over time.

The new direction integrates the forest ecosystem and the human element for management as a single system ordered toward a single goal. The goal is to bring the forest to a chosen state of organization. The particular state of organization is determined by the combination of benefits that is biologically possible and desired (Boyce 1978b).

The basic structure derived for the new direction is a dynamic planning technique that is fixed by the inherent mechanisms of biological processes. This biological structure amplifies the changes in the two control variables. When the control variables are used within the biological constraints, such as delays in succession, then the forest can be directed toward a particular state of organization and the availability of any combination of benefits can be predicted over time.

In both unmanaged and managed forests, ecosystem dynamics changes stand structure and the states of forest organization in relation to silviculture.

The Biological Structure of Forests

Structure is the way parts of a system are connected. The walls of a building are connected to form spaces useful for working, cooking, eating, playing, resting, and sleeping. The relative value of the benefits derived from a building are determined by the arrangement, the interrelation and the linkage of the walls, floors, doors, windows, and other parts. Different buildings provide different combinations of benefits primarily because different kinds of parts are structured in different ways. The combination of benefits available from both buildings and forest are determined by a structure.

Biological structure is the way plants and animals are arranged and connected to each other and to the physical environment. Biological structure results from ecosystem dynamics. Forest structure includes the arrangements and the dispersions of individuals, stands, and populations over time. Changes over time provide different combinations of benefits because different kinds of plants and animals are arranged and connected to form different kinds of stands, and the dispersion of these different kinds of stands determines the availability of human benefits.

The dynamics of stand structure is driven by mortality which results primarily from the mechanisms of natural selection. Mortality associated with natural selection is caused by the inability of individuals to maintain some essential variable within the limits for life. Essential variables include water content, rate of photosynthesis, absorption of nutrients, capture of food, sugar content of the blood, and physical integrity of the body. Mortalities are consequences of the physical and chemical behavior of each organism as controlled by a specific genetic code being translated in a specific, dynamic environment. Mortalities not only influence the kinds and proportions of genes transmitted to the next generation but also organize over time the structure of stands and the states of organization of forests.

Thus, the biological structure of unmanaged forests and the dynamics of this structure are determined by the processes of genetic mutation, recombination of the genetic code, and natural selection of phenotypes. Both the time-varying structures of forests and organic evolution are driven essentially by the same biological mechanisms. For the same reasons that organic evolution is aimless the natural, unmanaged forest is an aimless system (Boyce 1978b).

The significance of these relationships is that the unmanaged, aimless forest is, however, organized by mortality. There are orderly changes

in states of the forest system, although not as determinant as for the solar system. Future states of organization such as the dispersion of age and area classes of stands by forest type is difficult though not impossible to project for about a decade into the future. The dispersion of these stand condition classes is determined in unmanaged stands by mortality related to natural selection and by the irregularities of storms that may blow trees down; insects, diseases, or fire that may kill individual trees or contiguous areas of forest; and the death of very old trees. The initiation of new age classes is not orderly, but transformation from young to old age classes can be predicted.

Once a new stand is initiated in either unmanaged or managed forests, relative rates of mortality among the species present determine the rates of transformation of the stand from one condition class to another. Because of the similarity of genetic codes from generation to generation, the rates of transformation can be predicted once observed over some historic period.

Mortality is the primary mechanism that brings about the transformation of genetic and ecological structure. Mortality is to be used to direct orderly changes in the states of organization of forests.

Directing the States of Forest Organization

The most effective cultural technique is to selectively change rates of mortality of forest organisms. This practice merely mimics or modifies mortality associated with natural selection. For example, regulating the harvest of wildlife, the harvest of timber, the thinning of stands, the removal of undesirable insects, and the use of herbicides and fungicides are all examples of selectively changing rates of mortality of organisms. These cultural techniques speed the transformation from one stand structure to another, initiate the beginning of new stands, and change the species composition of stands. The significance of these relationships is that transformations can be ordered and future states of forest organization can be predicted.

The essential control variables are the rates of harvest and size of openings formed. All other cultural practices are in-place enhancements (Boyce 1977).

For all possible combinations of multiple benefits it is necessary to create all possible combinations of stand condition classes. These classes are called habitats. The different combinations of habitats changing spatially and temporally provide a livelihood for plants and animals and determine the availability of human benefits. This is achieved in practice by using superimposed rotations (Boyce 1977).

Superimposed rotations are implemented by harvesting a stand at age "A"; the succeeding stand on the same land may then be harvested at age "B". For most forests only two superimposed rotations are required to provide the required diversity of habitats. Superimposed rotations are used to modify the rates of harvest, which is one of the primary control variables. For two superimposed rotations the alternative rates of harvests are varied by choosing the two ages for harvesting and the proportion of area that is to succeed through the two ages. This relatively simple control variable provides for a very large number of alternative combinations of habitats and an equally large number of combinations of benefits.

The size of openings formed at the time of harvest determines the area classes of stands and the dispersion of stands. Dispersion of habitats can be expressed quantitatively as a function of the area of land harvested per year and the sizes of the openings formed. The size of openings, which over time determine the area classes of stands and the dispersion of habitats, increases the variety of habitats to an enormous number.

The enormous variety of habitats are directed over time. Proliferating complexity is constrained and different combinations of benefits are predicted in relation to alternative modes of management.

THE PREDICTION OF BENEFITS

The typical question forest managers attempt to answer is how much timber, water, wildlife, recreation and wilderness experience should be made available to users? An answer is difficult if not impossible to derive because of the complexity of projecting more than three or four benefits with an equal number of management actions. I described at the beginning of this paper how complexity proliferates to unmanageable proportions when the manager and his staff attempt to predict selected combinations of many benefits for alternative management actions.

The new direction for forest management provides a solution to this difficulty. First, I encourage the forest manager to ask a different kind of question: To what dynamic state of organization does the manager want to bring this forest? The answer is a single goal toward which all cultural actions are directed. Now the manager can schedule an orderly change in states of organization of the forest and for any moment of time the biologically possible combination of benefits can be predicted.

States are projected from the present state of the forest through all of the transformations to the goal, which is the desired state of organization. Since the goal usually cannot be achieved for about 100 years, the goal may need to be adjusted in relation to socioeconomic and political changes. Thus, the dynamic states and predictions

for benefits through the early transformations, the next decade, is important for choosing a mode of management.

For example, a yield table for timber relates an expected amount of timber to a future state of organization of the forest--the area and age class of stands. The yield table is operational when orderly changes in the states of forest organization provide a time-varying base for projecting the amount of area in the age classes. Since yield tables and their use are well known, I will not elaborate on this example. Rather, I will illustrate the application of the yield-table concept to the prediction of a potential livelihood for the white-tailed deer and the flicker woodpecker.

White-Tailed Deer

The adaptable white-tailed deer uses many habitats in the Southern Appalachian Mountains. The livelihood for this animal can be enhanced by bringing about an appropriate distribution of seedling, sapling, and mast-producing habitats. Seedling habitats provide browse, soft mast, and some cover. Sapling habitats provide escape cover and bedding areas. However, if rates of harvest maintain adequate seedling habitat then adequate sapling habitat will be available. The 10-inch pole and mature habitats provide hard mast and cover.

Size of openings are important, especially during the period of seedlings. Openings of about 1 to 6 acres provide for maximum use of the browse and adjacent stands provide escape cover. Openings larger than about 30 acres are not used as effectively as small openings.

These relationships can be expressed by tables (Table 1), charts, graphs, and equations. An index of the potential livelihood for deer is related to each of the three variables. The index ranges from 0 to 1.

When there is no seedling habitat the amount of browse and soft mast is very low and the index for deer is zero. As the proportion of the forest in seedling habitat increases, the contribution of this habitat to the deer index increases. When the rate of increase is found to vary from forest to forest, the tables are modified. For example, the maximum amount of seedling habitat that could be produced, because of constraints on timber harvest, is 7 percent. Therefore, the maximum contribution of this habitat to the deer index is set at 7 percent.

Hard mast is not essential for deer but an increase from 0 to 20 percent in the amount of hard mast habitat enhances the livelihood of deer. When there are no hard mast producing habitats the deer index is very low but not zero. When the amount of hard mast-producing habitats exceeds 20 percent of the forest, there is no additional benefit to the livelihood for deer. The maximum contribution of hard mast to the deer index is set at 20 percent.

Table 1.--Livelihood of white-tailed deer related to components of states of forest orginization in Southern Appalachian Mountains[1]

Index for livelihood of deer (dimensionless)	Percent of forest in:		Size of openings (acres)
	Seedling habitat	10-inch poles and mature habitat	
0.0	0.0	--	--
0.1	1.0	2.5	60+
0.2	2.0	5.0	60+
0.3	2.3	6.8	60+
0.4	2.6	8.6	55-60
0.5	3.0	10.0	49-54
0.6	3.5	11.8	43-48
0.7	4.0	13.6	37-42
0.8	5.0	15.0	25-36
0.9	6.0	17.5	7-24
1.0	7.0	20.0	1-6

[1](Boyce 1977:55-57.)

The most effectively used size of opening for browse is about 1 to 6 acres and the index for deer declines as the size of openings increases to about 60 acres. Larger openings do not reduce the deer index any more than 60-acre openings.

Since the indexes are all on a scale of 0 to 1, values for the three relationships can be reduced to a single number by multiplication. Any other mathematical calculation is possible but multiplication is simple.

At any moment of time during the orderly transformation of a forest toward a desired state of organization, the index for the livelihood of deer can be calculated. Assume a forest state with 3-percent seedling habitat, 15-percent mast-producing habitat, and 5-acre openings being formed by timber harvest. The deer index would be calculated by $.5 \times .8 \times 1 = .4$. As the forest continues to transform from state to state, the change in the index for livelihood of deer can be computed. Thus, the potential livelihood for deer is predicted over time in relation to one or more alternative modes of management.

Flicker Woodpecker

The important variables for the livelihood of flicker woodpecker are seedling, mature and old growth habitats, and size of openings (Table 2). If the state of organization of the forest provides 4-percent seedling habitat, 5 percent mature and old growth habitats, and 5-acre openings, the

Table 2.--Livelihood of flicker woodpecker related to components of states of forest organization in the Southern Appalachian Mountains[1]

Index for livelihood of flicker woodpecker (dimensionless)	Percent of forest in:		Size of openings (acres)
	Seedling habitat	Mature and old growth habitats	
0.0	--	[2]	--
0.1	0.5	[2]	2.00
0.2	1.2	[2]	2.75
0.3	2.0	[2]	3.00
0.4	2.5	[2]	3.75
0.5	3.0	0.0	4.00
0.6	3.5	1.8	4.75
0.7	4.0	3.7	5.00
0.8	4.5	5.0	5.75
0.9	5.0	10.0	6.00
1.0	7.0	20.0	10.00

[1](Boyce 1977:64-67.)

[2]No old growth and mature habitats.

index for flicker is 0.39. This is calculated by multiplying the respective index values for each variable (.7 x .8 x .7).

The indexes for flicker and deer are calculated independently of each other, yet both are related in that each is determined by the orderly changes in the states of forest organization. This procedure constrains complexity because interaction coefficients for large matrices are not needed. It is only necessary for specialists and scientists in different disciplines (Boyce 1979) to develop relatively simple tables, charts, graphs and equations (see Table 1 and 2). The mathematical expressions relate the availability of a benefit in a particular discipline to the orderly changes in states of the forest.

Other Benefits

Any benefit or impact that can be related to states of forest organization can be projected over time. Some examples are scenic values, sediment production, visual appeal, ugliness, and stream flows (Boyce 1977).

CONTROL

Complexity is constrained to the use of two control variables for systematically ordering the ecosystem dynamics of the forest and to the choice of a single goal, namely a state of forest organization. The enormous variety of large numbers of benefits and associated cultural practices is absorbed by the equal variety of habitats which are dispersed spatially and temporally by the rate of harvest and the size of openings.

The mathematical techniques for projecting benefits in relation to alternative modes of management are described (Boyce 1977, 1978a,b). The control method uses a system dynamics model (Forrester 1961). The model simulates the ecosystem dynamics for any forest that can be described in spatial and temporal changes in the age and area classes of stands by forest type. The simulation model, the principles, the theories, and the operational techniques are called the Dynamic Analytic Silviculture Technique; the acronym is DYNAST.

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EL PRONOSTICO DE PROVECHOS MULTIPLES DE LA SILVICULTURA

Estas hojas describen una manera metódica para proyectar, gobernar, y dirigir la transformación de bosques de un estado al otro. Esta transformación reglada provee variables por el tiempo, a saber, la dispersión temporal y del espacio de los medios que se puede emplear para predicar el potential de toda clase de provechos para el bosque sólo y en combinación.

LA PREDICTION DES BIENFAITS MULTIPLES DE LA SILVICULTURE

Cette communication décrit une manière méthodique pour projeter, régler et diriger la transformation de forêts d'un état à autre. Cette transformation rangée fournit des variables en temps, c'est-à-dire, la dispersion temporelle et spatiale des habitats que l'on peut employer pour prédire le potentiel pour toute sorte de bienfaits forestiers seul et en combinaison.

DAS VORHERSAGEN VON VIELFACHEN VORTEILEN VON DER FORSTKULTUR

Dieser Bericht beschreibt eine regelmässige Methode, um die Waldumformung von einem Zustand zu einem andern zu beabsichtigen, regulieren und überwachen. Diese geordnete Umformung liefert Zeitvariabel, nämlich, die zeitliche und räumliche Verbreitung von Heimaten, die man benutzen kann, um die Möglichkeiten aller Waldvorteile allein und miteinander vorherzusagen.

Session II

Status and Progress of Multiple-Use Research

Marc Dourojeanni, Moderator

Universidad National Agraria Apartado, Peru

Summary of presented papers:

There is a need for a more conceptual framework about multiple use of forests, such as stressed by Mr. Anko, based upon long European experience. Mr. Anko discussed very clearly the basic differences between multiple use and multiple functions, and the consequences of this second concept for research and management.

Mr. Kaul, in a comprehensive review of the status of the impact of forest land use on environment in India, gave us a good approach to the kind of work which could be and must be done in every country, but mainly in developing countries, before starting any big program of research in multiple use. His main conclusion, as in the former paper, is that there is need for more research on multiple use. But, with the kind of systematic correlation he made between forest functions and every relevant social and economic problem of the rural and general development, it is almost certain that results of research will be convincing for decision makers and through them, will be useful.

The question more frequently raised about multiple use is how to be able to combine and correlate such a number and diversity of interacting factors to be taken into account in management plans, in a reasonable time and/or with a reasonable possibility of success. As part of the solution of this, we were pleased to listen to Dr. Chang's exposition about multiple-use forest management by goal programming input-output analysis, which seems indeed to be a promising method.

From the tropical region of Mexico we learned of research about some of the aspects that Dr. King pointed out yesterday as beging of the greatest importance. Combinations of traditional agricultural crops or forages for cattle with reforestation were established as part of a long-term research program, in order to obtain answers about the economic and social viability of each of the many possible alternatives. The research conducted by Mr. Cedeno and Mr. Chavelas is seconded by a growing number of small or medium size projects like their own in many countries of Latin America as in Africa and Asia, as we have learned from Dr. Okigbo and Mr. Kermani. Of course much more needs to be done, and probably in a more systematic way.

Finally, Mr. Karschon, through Mr. Gottfried, brought us an Israeli experience, showing that despite the important reforestation made and the great advantages of a multiple-use forest approach in such a dry country, relatively little has been done, especially from the research point of view. But data are available and some new techniques, for instance, were used for research in recreation potential.

Summary of session 2:

Much research has been done on multiple use forests during the past decade, and hopefully, a great deal of it was used in developing countries. So there are reasons to be optimistic. But, from what was explained during the session, it is possible to make the following observations:

a) Much more research is needed, speaking in general terms;
b) There is a special need for research in the field of the "protection" function (Anko's concept) in both developed and underdeveloped countries in which many of the protection forests are not managed at all;
c) Research and development in multiple-use forestry must be more interdisciplinary than at present, and also, must be better integrated with rural development;
d) There is not yet a totally satisfactory answer to the problem of quick and practical methods for planning multiple use management;
e) Despite all that has been done in the past to quantify or valerise the forest functions, much more effort is yet necessary;
f) In developing countries, a strong effort must be made in the field of production of food and energy from the forests and forest soils.

Concepts of Multiple-Use Research — A Perspective Based on Experience in the Alpine Region[1]

Boštjan Anko[2]

Abstract. A distinction between the terms "forest use" and "forest function" has been proposed. From the research and management point of view the control method seems to be ideally suited to the studies of dynamic steering of processes such as forest functions.

INTRODUCTION

The concept of multiple-use forestry has emerged as a response to scarcity of forest resource, and to one-sided forest utilization that either destroyed forest as such or brought about serious conflicts between the traditional and newly arising functions of the forest.

The history of development of the idea of multiple-use forest and forestry in the United States, for example, is rather different from the one in Europe: there are shifts in time, extent and intensity in man-forest relations, yet it is possible to discern some common denominators in both developments - at different points in time.

As one such point one could consider, for instance, the time of settlement. Although white man's settlement of the New World varies from the early medieval colonization of Europe it does show some common features in man-forest relations: at the beginning the forest is virtually an enemy-the arable land has to be cleared to secure human existence, wood has practically no commercial value, forests separate human communities at all levels, etc.

A whole millenium separates both processes and this fact explains some temporal and qualitative differences in man-forest relations in North America and in Europe: the relatively densely populated and politically fragmented Europe experienced the emergence of relatively large urban centers while still in a feudal social order.

Any large concentration of population (such as cities) imposes great demands upon the forest resource. Thus the limited forest resource further limited by the lack of transportation facilities first gave birth to the idea of sustained yield and rather soon thereafter also to the idea and practice of multiple-use forestry. This is why the concept of multiple-use forestry had been practiced in Europe long before it was given a name.

The United States entered the "age of urbanization" free of the hindering traditions, with large forest resource still available at the new frontiers of the West. The American cities emerged in an entirely different political and economic order in time of a higher developed trade and means of transportation. There was no need for them to own their own forests or pastures as it was for their European counterparts.

FOREST USE AND FOREST FUNCTION

The longer evolutionary path of man-forest relations in Europe must have resulted in a different attitude toward the forest. There were no new frontiers for the Europeans and soon they had to become aware of the fact that the forest is a very limited resource. In view of this European man soon realized that there is more to the forest than wood and pasturage alone and this is perhaps why we find in European literature rather early a term "forest function" which implies a somewhat different attitude toward the benefits arriving from the forest than the term "forest use" which seems to be exclusively man-oriented.

This is why we prefer to talk about forest functions, rather than of forest uses. From ecological point of view forests performed most of the functions we know today in primeval landscapes already: they produced wood as a part of the forest biomass, they prevented erosion and landslides, they modified climate, they influenced the water runoff etc.

Only when these functions are being put to human uses they become forest uses. The word "use" thus implies a direct benefit arriving from a certain course of action. But there are also many indirect benefits involved such as protection of soils, modification of climate etc., which could hardly be called direct forest-uses and yet they have to be taken into consideration in forest management. Thus the purpose of our forest

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[1]Paper presented at the IUFRO/MAB Conference, Flagstaff, Arizona, May 18-23, 1980

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management should not be pursuing direct benefits alone, but strenghtening the capability of the forest to perform all of its functions in the future as well. In view of the long production periods of the forest this seems to be also the safer approach which allows for more flexibility. There is, namely, one more difference between a forest function and a forest use: function as an ecological feature of the forest represents a rather absolute entity. Use, on the other hand is an anthropocentric notion: as such it is subject to rather fast changes in time, place, technology, social and cultural givens etc.

It is rather difficult therefore to predict the use of the newly regenerated stand by the time it will reach its maturity. A little easier, perhaps, can we forecast the functions this stand is to perform during its lifetime. The functional orientation of the forest management may thus also give an answer to the question as to what is an ideal multiple-use or multi-functional forest: we see it as a natural forest, managed with a consideration of all the functions it is capable and likely to perform. Its closeness to natural structure and composition should guarantee the stability and at the same time the flexibility needed for this porpose.

DIVISION OF FOREST FUNCTIONS

The research of forest functions and management for them requires that they be suitably divided. It is namely quite obvious that there are essential differences among them.

The first group consists of productive functions which are closely related to the biomass production of the forest ecosystem. Wood, pasturage, game and numerous side- products are the longest known benefits from the forest.

To the second group belong the numerous ecological functions the forest performs as an ecological element of the landscape. Our legislation, for example, explicitly calls for consideration of: protective, water, climatic and health-hygienic function.

The third group contains the so-called social functions such as recreation, education, aesthetics, preservation of natural and historic heritage and national defense.

The essential differences among the three groups mentioned are obvious:

The first group is closely related to the forest as a primary producer. Converting these functions into direct uses with tangible benefits is, in fact, the art and essence of the traditional forestry.

The second group consists of the functions the forest as a whole performs as an environmental element. The beneficial effects of the forest upon the ecology of cultural landscape in particular has long been known - yet only partially and locally, only in cases where these effects were direct and obvious (protection from wind, frost, avalanches etc.). Universally, these functions have been recognized only with the development of ecology and with our increasing environmental awareness. This is an area of "semitangible" ecological benefits as well as of rather fundamental questions considering the importance of the presence of the forest in the cultural landscape where forest as most highly developed ecosystem represents a counterweight to man-made ecosystems, maintains naturalness, preserves genetic variety, etc.

As such this group of functions is rather new to the forestry. Considering it requires a somewhat different, broader view of the forest - a view from without. The study of these functions goes beyond the boundaries of the forest ecology itself: it enters the new field of landscape ecology. In this context forestry is not only an economic activity as it is in the case of productive function, but also an important environment-shaping human activity.

The distinction between "use" and "function" is least clearly defined in the case of the so-called social functions. Although these functions do depend on the nature of the forest they are largely conditioned by the cultural specifics of a given society, such as tradition, social and economic order, attitudes of the general public toward the forest etc. No forest can perform these functions unless they are required by man. In their case the causal order function-use changes into use-function. Man is the principal agent and variable in this process. The study of these functions therefore requires different approaches and techniques which have to be borrowed from a variety of disciplines as distant and at the first glance as unrelated as sociology, aesthetics, demography, military doctrine, psychology, history and so forth.

None of the above disciplines can solve the problems related to the research of these functions by itself. This reasearch requires interdisciplinary approaches and techniques which can be developed only in close collaboration of the forestry with the disciplines mentioned. The research of and management for the social functions thus means broadening the field of work of traditional forestry.

MANAGEMENT FOR VARIOUS FUNCTIONS OF THE FOREST

The Slovene legislation has declared forests as a public good of special significance - regardless of the ownership, similarly as, for instance, in Switzerland. Among other things this also means a free access to the forest for everybody. All the forests are managed according to the same silvicultural principles. Clearcutting has been forbidden since 1949. The Forestry bill of 1974 also requires that forestry operating on entirely economic basis (i.e. without state subsidies)

should manage all the forests in a manner that would guarantee development and strenghtening of all the forest functions.

Until very recently it has been commonly accepted that a natural, properly managed forest producing timber in a satisfactory manner performs or is capable of performing all the remaining functions equally well. In other words, it had been felt that the other functions needed no special consideration and were perfectly compatible with the productive one. In view of the pronatural orientation of our forestry this may really have been so: with the rapid industrialization and urbanization of the country, accompanied by some rather extensive interventions in the forested landscape (construction of pipelines, power-lines, highways, construction of second homes, air pollution damages to the forest etc.), however, this notion had to change somewhat. The increased significance of environmental and social functions of the forest became more obvious. In many cases these functions could not be taken for granted any longer. They began to require a special attention in the form of research and special management measures.

Thus the present practice of multiple-use or multifunctional forestry in Slovenia operates at two levels:

1. Wherever the demands after environmental and social functions of the forest are compatible with the general forestry practice it is considered that these functions are contained in the productive function as practiced.

2. In cases where pressures upon forest as ecosystem and as a resource are more intensive, attempts are being made to optimize all the functions.

In planning theory as well as in practice there should be no difference among management principles for various functions. Forest as a live system frequently reacts upon different inputs, i. e. natural, social, economic changes as reflected in various management measures in a rather unpredictable manner. As a result, management of forest resource for any given function is, in fact, a dynamic steering of natural processes in a direction desired. In this connection forest may be considered as a "black box" system in which numerous processes, not fully known or understood act upon management measures (input). As a result the outputs (the quality or quantity of the function managed for, the ecological processes in the forest etc.) are very seldomly what they were expected to be: the difference between the expected situation and the existing one contains the feedback information that, in turn, influences our next step, i. e. management measure.

Considering this we have to appreciate that a given objective can only seldomly be reached by a single management intervention. The more distant is the objective in time, the more corrective measures will be required to attain it. The quality, quantity and timing of such management measures will thus depend on the feedback.

This management principle which is widely applicable in management of all renewable natural resources has been developed by forestry long before the birth of cybernetics. The "Postojna controll method" has been practiced in parts of Slovenia for nearly a century. It has been developed for productive function. The meticulous registration of dendrometric and structural changes of the forest as a reaction to the forest management practices through nearly a century represents an invaluable tool in intermediate and long-term management planning in these forests.

THE NEED FOR RELATED RESEARCH

Slovenia is one of the fortunate countries where one can ski in the mountains and swim in the warm Adriatic sea in one day. Considering its small size this implies an extraordinary variety in natural conditions. It varies also from the neighbouring countries in several socio-economic aspects.

As mentioned earlier very little needed to and has been done so far with respect to multifunctional forestry. The kind of forestry as practiced in the country really guaranteed a satisfactory performance of all the functions. The changing situation, however, required that more attention be given to the environmental and social functions of the forest. This also coincided with the elaboration of a new generation of obligatory 10-year forest management plans for the period 1981-1990.

The content of these plans differs significantly from that of the past ones. They reflect a new role of forestry which is no longer merely a wood producing enterprise but rather an economic and at the same time an environment protecting and shaping activity, dependent on a series of natural, social and technical factors and influencing man's environment and the quality of life in it.

Such a change with a stress upon various forest functions certainly requires new ways of thinking, new approaches, methodologies etc.. A series of workshops have been organized by the Ljubljana Forestry School for the practicing foresters and several new courses have been introduced in the study programs for the future ones.

The study of forest functions was given an additional impetus by the legislation regulating land-use planning which was passed in 1978.

Most land-uses appear to be more profitable (at least in the short run) than the forestry if only the direct benefits (timber) are considered. The defense of forest areas designated for other land-uses or against unreasonable interventions in a forested landscape seems to be much more efficient when the other functions of the forest are being considered as well. For these purposes we find that it is very expedient to have an

overview of the forest areas where individual forest functions are of an above average significance. A special methodoloy for designating such areas has been developed and right now we are in the process of obtaining a map of such forest areas for the entire country in a scale 1:25.000. The more such functions overlap in a given area the more important it should be - for the forestry and in general. By means of these maps the priority areas for forest land-use are elaborated. They represent the obligatory contribution of the forestry to the land-use planning process which is somewhat different in Yugoslavia than in other countries. Our land-use plans, as a rule, are not prepared by specialized planning organizations: land requirements are submitted in the form of "priority areas" by all the parties concerned (e.g. agriculture, industry, urbanization, transportation, forestry etc.). Then these needs are confronted and coordinated according to the general strategies, goals and objectives for the development of a region. In such a process it is obvious that the forestry cause will be adequately represented only if the importance of various environmental and social forest functions will be interpreted appropriately.

There is another benefit we expect from these maps: for the first time we shall have for the entire country an overview of the forest areas where individual functions are of special significance. As an inventory obtained with a uniform methodology it should render possible the fundamental research on these functions.

SOME THOUGHTS ON THE RESEARCH IN THE FUTURE

Time and again when confronted with a task of writing an environmental impact statement, for example, we find that the research results from elsewhere are not readily transferable to the natural as well as socio-economic specifics of the country. The relatively abundant research done on environmental functions of the forest, for example, inGermany is hardly of any use, since it had been done in different natural conditions. The excellent research on recreational function done in the U.S.A. is only of interest to us as far as basics and methodologies are concerned, and so forth.

All this calls for original fundamental research on forest functions. This, however, is an extremely demanding task, requiring a lot of research -workers, funds and time, none of which is readily available.

Such a situation requires several things:

1. a list of research priorities
2. division of research work between forestry and other disciplines
3. developing interdisciplinary research projects
4. answering some fundamental questions regarding the research on forest functions.

Ad 1./

All the forest functions ought to be treated as equal. Nevertheless, the protective function of the forests seems to be the first among the equals. At present we have thousands of hectares of forests on extreme sites, designated as protective forests. In most cases such a designation means simply no management. Considering the fact that these forests have been proclaimed as such a long time ago by no uniform methodology, frequently only on the grounds of inaccessibility, we feel that their status should be re-examined. It is also questionable whether the "management" attitude is really the best one as far as this function is concerned. Dead trees, for examle, may represent a fire hazard, there may be problems of rejuvenation of some stands etc. In general it is felt that we know far too little about this function in view of its extraordinary importance.

Another function requiring a prompt attention is the recreational one. The crowds of recreationists and the multitude of their requirements have found the foresters by and large unprepared and unqualified to handle either the crowds or the forest as a recreational resource. As yet we have no specialists for this function and we are sorely lacking any kind of data on recreationists and their impact on the forest.

Ad 2./

The amount of research work on forest functions is staggering. And yet, all too frequently one has the impression that the foresters are jealous of anyone else trying to do research in the forest. A lot of fundamental research could be done, for example by sociologists, hydrologists, biologists, properly oriented soil scientists etc.. The profession will have to open up - it can only benefit from it.

Ad 3./

There is also a lot of applied research related to the forest functions that needs to be done. This is the field of interdisciplinary research which is becoming a must in as complex a discipline as forestry which borders on so many scientific disciplines. A certain mental block seems to exist here too, which appears to be related to the general profile of a forester. As a professional with a blend of backgrounds as different as social sciences, biology and technics, the forester seems to be reluctant to deal with various specialists that may be needed. He appears to be unaware of the advantages of his varied background which may qualify him better than anyone else for the synthesis required by any interdisciplinary effort. This seems to be specially a problem of a small nation with a relatively small number of specialized foresters.

Ad 4./

A lot of time and effort has been spent in attempts to quantify the functions of the forest.

Through centuries of its existence forestry has developed very accurate methods of quantifying the productive function. Cubic feet or cubic meters in addition can also easily be converted into monetary quantities.

Quantification of environmental functions of the forest represents quite a different task. Firstly, the benefits these functions represent are very difficult to measure. Secondly, they have no common measuring unit. Thirdly, there is virtually no way of converting these benefits into monetary terms. It has been frequently attempted to find, for the sake of convenience, a common denominator for them. It is true that there are many conceptual difficulties involved in appreciating these functions - especially for a layman - which make the monetary expression of such a function most easily understood. And the foresters are trying to oblige by calculating such absurd things,as, for instance, the monetary value of reduction of wind speed from ten to five meters per second... This phenomenon too may have something to do with the reputation forestry as discipline of applied science enjoys among the general public: seldomly do people question the work of chemists, physicists etc.: the foresters, however, their actions and statements are all too frequently exposed to justified or unjustified criticism. This is why we feel that the educational function of the forest is so very important. One has to admit, however, that the situation is gradually improving. With increasing environmental awareness it is becoming clear to more and more people that there is something rather absolute to the presence of the forest in the landscape - something that cannot be expressed in monetary terms.

So let us stick to our tons, percents, minutes per second - but only as far as these quantities will help our understanding of the environmental functions of the forest - and management for them.

The matter of quantification of forest functions becomes most complicated in case of the social functions. This question largely depends on the socio-economic status of the forest in a given society. In Europe several legislations have declared forest as a public good of special importance - regardless of the ownership. Such an attitude which has evolved through centuries long awareness of the scarcity and beneficial effects of the forest is somewhat different from the North American one, although one could also trace the beginnings of similar attitudes in the recent anticlearcutting campaign in the United States.

Again the most suitable unit for expressing these functions seems to be money. It may be useful in cost-benefit analysis for the forests managed exclusively as recreation areas, reserves,etc. Yet it becomes completely irrelevant in a case of a multifunctional forest, declared as a public good of special significance and managed as such. The intangible benefits of these functions constitute a part of the quality of life which in itself is an absolute entity. No individual puts price on his life, most parents put no price on their children's welfare and no society puts a price on its freedom. Equally one should say that no forestry operating under similar circumstances as ours may put a price on the social functions. This, of course does not mean that unlimited resources should or could be made available for these functions - as they are usually not in the case of an individual, family or society. Forestry should only aim at the highest level of performance attainable in given circumstances.

Even if we do not attempt to quantify the social functions as a whole, there is a lot to quantify with regard to parameters helping us understand certain laws pertaining to them and improve the management techniques.

To quantify or not to quantify? There seem to be two directions of thought regarding this question. The first one claiming that due to the complexity of these functions nothing can be quantified and the second one maintaining that everything has to be quantified. As usually the answer seems to be somewhere in the middle. But we believe that more important is the question what to quantify and for what purpose. Do we quantify to obtain public recognition of these functions or do we quantify to reach a better understanding thereof - for a more efficient management?

Here we should recall the model of a forest as a "black box" system with the feedback indicating the behaviour of the system, thus also gradually explaining its functioning. From the management point of view the most interesting relations to be quantified are those existing between the inputs and the outputs of such a system. Forest is a living system with these relations changing constantly. As a result a dynamic approach to expressing forest functions is needed rather than a stationary one, represented by attempts to quantify a function as a whole, sometimes also in the form of so frequently misinterpreted carrying capacity.

The idea of dynamic approach is well suited to the control method, mentioned earlier. Most natural processes (functions) evolve slowly, therefore a point in time cannot represent their trends. With this regard we frequently seem to be too impatient when trying to grasp the entire process from one point only. The value of control method data grows with the duration of observations: the time is an indispensable element of understanding natural processes. The main stress in work on quantifying forest functions should thus be given to quantifying input-output relations with respect to individual functions and relations among them.

In the following we would like to give an example of the application of control method in wildlife and forest management by Postojna forest enterprise in vicinity of Ljubljana, where an abnormally high deer population held in check forest rejuvenation on large areas. According to the traditional wildlife management principles they first attempted to deal with the problem by trying to establish the number of deer population in the area and then to find a tolerable desity of this population that would still allow the regeneration

of the forest. After several years of futile efforts and considerable expense they had to give up: apparently the population density was not the right parameter chosen. Therefore they devised an approach according to the control method. It is known that overpopulation of deer reduces the weight especially that of the youngest animals. They set up a system of control plots to register the changes in browsing damage to the vegetation and increased the number of shot-off deer for several successive years. Rather soon it became obvious that there is a direct correlation between the weight of the animals and the antlers, and reduced damages to the vegetation. In theory at least the problem has been solved: instead of a stationary parameter - population density, which can never be determined nearly accurately, a couple of easily quantifyable parameters is being used which render themselves excellently to the control method.

In the future, therefore we expect to put more emphasis on studying and quantifying individual input - output relations pertaining to individual functions, rather than the functions as a whole by aplication of the control method. This is not an easy method. Nor does it yield quick results, still in the long run it seems to be a rather promising proposition for multifunctional forestry.

CONCEPTOS DE INVESTIGACION DE USO MULTIPLE: UNA PERSPECTIVA BASADA EN LA EXPERIENCIA EN LA REGION ALPINA

El concepto del aprovechamiento múltiple forestal resulta del conocimiento de que los recursos forestales son limitados y que las nuevas maneras de enfocar en las funciones forestales son más razonables para repartir componentes escasos que el método tradicional de aprovechamiento único. El desarollo del concepto de aprovechamiento múltiple forestal combina la relación entre el hombre y el bosque.

Distinguimos entre tres grupos de funciones forestales: la producción económica del rendimiento, la protección del medio ambiente y las funciones sociales. Cada una de estas funciones requiere un tipo especial de investigación técnica para explicar su propia peculiaridad. Al principio es mejor cuantificar la relación entre entrada y rendimiento de las funciones en vez de cuantificar las funciones como artículos independientes. El método de control puede ser muy apropiado para este objetivo.

CONCEPTS DE RECHERCHES SUR L'USAGE MULTIPLE: UNE PERSPECTIVE BASEE SUR L'EXPERIENCE DANS LA REGION ALPINE

La conception d'une foresterie à multiple dessein se développa en réaction contre l'insuffisance de ressources forestières et contre l'usage unilatéral de la forêt laquelle il l'en a ou totalement détruit ou bien a-t-il provoqué de conflits sérieux entre ses usages traditionnels et ceux qui prennent la naissance nouvelle.

Le développement d'idée d'une forêt à multiple dessein ou à multiple fonction est lié étroitement au développement des rapports l'homme - la forêt.

De par leur nature, les fonctions de la forêt peuvent être divisées en trois groupes: de production, de créateur environmental et sociale.

Chacun d'eux demande une technique spéciale de recherche du point de vue de sa nature et de la reconnaissance générale de la signification de fonction. Il paraît, si l'on tient compte que la forêt se comporte en écosystème vivant, que la quantification des rapports input-output des fonctions particulières et leurs rapports réciproques donne de résultats meilleurs que les tentatives de quantifier la fonction en totalité. Pour aborder la question ainsi, paraît-il la méthode controlle spécialement appropriée.

RICHTLINIEN FUR VIELFALTIGE NUTZUNGSFORSCHUNG--EINE PERSPEKTIVE AUF FORSCHUNG IN DER ALPINE REGION GEGRUNDET

Das Konzept der Mehrzweckforstwirtschaft ist aus der Erkenntniss entstanden, dass die forstlichen Reserven ungenügend sind und dass die einseitige Forstbenutzung Waldverwüstungen oder schwere Gegensätze zwischen den traditionellen und den neuen Waldfunktionen verursacht.

Die Entwicklung der Idee der Mehrzweckforstwirtschaft ist mit der Entwicklung der Beziehungen zwischen Mensch und Wald eng verbunden.

Wir unterscheiden zwischen drei Gruppen von Waldfunktionen: wirtschaftliche, Schutz- und Soziale Funktionen.

Jede von diesen Gruppen verlangt ihre eigenen Forschungstechniken entsprechend der Eigenartigkeit der Funktion und der Bedeutung, die ihr zuerkannt wird.

Vorausgesetzt, dass sich der Wald wie ein System verhält, scheint die Quantifizierung der Input-Output Beziehungen für einzelne Funktionen und ihre gegenseitige Beziehungen bessere Ergebnisse zu bringen, als die Quantifizierung einer Funktion als ein Ganzes. Die Kontrollmethode kann für diesen Zweck sehr geeignet sein.

Impact of Forest Land Uses on Environment in India[1]

O. N. Kaul[2]

Abstract.--Multiple use of forest lands is a necessity born out of resource scarcity and growing population. The paper reports the environmental impacts of forest land uses in India and brings out that not much research has been done on combination of uses on forest lands. Future research needs have been indicated.

INTRODUCTION

Forest ecosystems in India occupy nearly 75 million ha constituting over one-fifth (22.8 percent) of the total land area of the country (C.F.C., 1977), forestry being a major land use next only to agriculture (Table 1). Over 46 percent of the total land area is under agriculture (probably the highest in the world) and over 30 percent is under other uses including potentially productive areas under forest or agriculture but at present lying barren, being the so called 'wasteland' of the country, the extent of which is estimated to be about 43 million ha (13 percent of the total land area) (N.C.A., 1973).

Table 1. Land utilisation in India

Land use	Area (Million ha)		% of the total
Agriculture (Cultivated land)	152.6		46.4
Forests	75.0		22.8
(a) Natural	72.9)	22.2)	
(b) Man-made	2.1)	0.6)	
Other uncultivated land	42.3		12.9
Land under non-agricultural uses	16.2		4.9
Barren and unculturable land	42.7		13.0
Total	328.8		100.0

[1]Paper presented at the IUFRO/MAB Conference on Research on Multiple-Use of Forest Resources, Flagstaff, Arizona, May 18-23, 1980.

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The extent of the forest area (75 million ha) mentioned above does not reveal the actual position as the figures indicate (C.F.C., 1977) in as much as the spatial distribution of forests is very unequal and unbalanced and only about 60.5 million ha are either exploited (42.7 million ha) or potentially exploitable (17.8 million ha), the remaining forest area being either inaccessible or unproductive or required to be maintained for protection purposes. Major portion of forests grow in undeveloped areas either because of the mountainous nature of the terrain, poor soil, or because of low pressure of human population, inaccessibility, etc. The outer Himalayas constitute one of the main forest belts of the country supplemented by large areas in the Western Ghats, Deccan Plateau, Eastern Ghats and the Northeast region. While the Himalayan forests and evergreen forests of the West Coast and the Northeast have a dense stocking, large areas in the Central Indian region, Indo-Gangetic plain and in the coastal strips and in other fertile valley systems are either partially stocked or entirely devoid of forests.

It may however, be noted that in the more humid part of these plains and valleys, the lack of forests is made up to a substantial extent by tree lands and groves which perform the same function as regards conservation of the environment, and as anti-pollutants in general. This is however, not true of the semi-arid and arid regions to the same extent, especially of the western reaches of the Indus plain and the Thar desert. A major proportion of fuelwood requirements of the country are met from these tree lands and groves, the so called 'unrecorded sources'.

The extensive dispersion of forests over the subcontinent is accompanied by great diversity in their specific composition. Accordingly the forests of the country have been divided into 16 Type-Groups (Champion and Seth, 1968) ranging from Tropical Wet Evergreen Forests to Alpine types; the tropical deciduous types (both moist and dry) constituting the bulk (70 percent) of the forests (Table 2; Kaul and Sharma, 1971). Whereas high

mountainous areas carry relatively pure forests of coniferous species (4.24 million ha; 5.6 percent of the total forest area) and there are extensive gregarious forests of Shorea robusta (16 percent), Tectona grandis (13 percent), and a few other species of local occurrence, the moister semi-evergreen and evergreen forests are composed of a large number of species. Bamboos (including plantations) occur over an area of 9.57 million ha (12.8 percent) (C.F.C., 1977). Consequently the utility of different species and their value in the context of present use as well as future utilisation varies enormously from region to region. Most of our forests are natural and although over 100 years of conservancy and protection have improved their stocking to a considerable degree, the overall density of these forests is by no means optimum.

Table 2. Forest area under different forest types

Type-Group	Area (Million ha)	% of the total
Tropical wet evergreen	4.5	6.0
Tropical semi-evergreen	1.8	2.5
Tropical moist deciduous	23.3	30.9
Littoral and swamp	0.6	0.9
Tropical dry deciduous	29.1	38.7
Tropical thorn	5.2	6.9
Tropical dry evergreen	0.1	0.1
Subtropical broadleaved hill	0.3	0.4
Subtropical pine	3.7	5.0
Subtropical dry evergreen	0.2	0.2
Montane wet temperate	1.6	2.1
Himalayan moist temperate	2.7	3.6
Himalayan dry temperate	0.2	0.3
Subalpine forests) Moist alpine scrub) Dry alpine scrub)	1.8	2.4

WHY MULTIPLE USE?

Multiple use of forest lands means the management of forest in a manner that, while conserving the basic land resource, will yield a high level of production in five major uses - wood, forage, water, recreation and wildlife - for the benefit of the greatest number of people in the long run (Anonymous, 1960). To these five major uses we may add a sixth one - food - the concept of agroforestry (King, 1979) which has been practised in India for a long time. This is necessary because the developing nations have to produce food in sufficient quantities and of adequate quality for their growing population. The problem is made all the more difficult because it is not only a question of producing this basic need but also to conserve and enhance the quality of the ecosystems used for such production.

Forest ecosystems in India have been providing a variety of forest products and services for long past. But the rising demands for these goods and services due to rapidly increasing population which has to be fed and given a better standard of living after centuries of static growth, increasing livestock population and growing competition of land for agricultural and other urban uses coupled with the low productivity of our forests has caused India to be classified on the world map of forest resources as belonging to a 'deficit zone'. As population has increased and industrialisation and urbanisation have progressed, the demands for forest products and other services that the forests provide have sprung up suddenly to find the foresters and forests alike ill-prepared to fulfil them.

The future demands of various goods and services on our forest ecosystems would primarily be influenced by the increase in population and economic growth though in case of fuelwood consumption, urbanization and the energy crisis would continue to have a significant effect. Population estimates as of July 1, of the relevant years on the basis of the revised (final) estimates are indicated in Table 3 (Thaper, 1974). The alarming rate of population increase (nearly 25 percent in the decade 1961-1971 and which is going to be almost doubled by the year 2000) has built up immense pressures on our forest ecosystems in terms of increased raw material demands and services which cannot be fully met resulting in the detrimental effect of population increase on these ecosystems. The impact of dynamic population growth arises the need for increased resources and the competition for land becoming more intense. Table 4 indicates the forest area lost for various purposes in the country during the period 1951 to 1973 (Chakravarty, 1974) which is to the tune of nearly 3.5 million ha, and which is going to increase in the coming decades.

Table 3. Estimates of population

Year	Population (Million)		
	Total	Urban	Rural
1961	442.21	79.60	362.60
1971	550.24	110.07	440.17
1980	650.63	160.02	490.61
1985	702.68	196.98	505.70
2000	863.99	409.23	454.76

Table 4. Forest area lost

	Area (000 ha)
Agricultural activities	2,432.47
Submerged due to river valley projects	401.48
Industries and townships	124.63
Transmission lines, roads, etc.	54.77
Miscellaneous uses	387.70
Total	3,401.05

Based on population growth and economic development the estimates of future requirements of wood are shown in Table 5 (N.C.A., 1972, 1976), indicating a substantial rise in the requirement of both industrial and fuelwood by the year 2000. Since the preparation of these estimates, a significant change has taken place due to energy crisis making it difficult to have alternative sources of energy available more freely and cheaply. Keeping this important point in view, the fact that private sources of fuelwood (which supply greater part of fuelwood requirements of the country) are fast dwindling and the use of plant biomass as a source of energy, the demands of fuelwood would be much greater than anticipated in the above estimates. Thaper (1974) has thus put the anticipated demand of fuelwood in the year 2001 at 385 million cubic metres.

Table 5. Aggregate wood raw material requirements

Forest products	Projected demands in 1980	1985	2000
Industrial wood ($000\ m^3$ round)			
High income growth	26,895	35,180	64,450
Low income growth	25,005	30,030	47,180
Fuelwood ($000\ m^3$)	184,000	202,000	225,000
Bamboo (000 tonnes)			
For pulp and paper			
High estimate	2,165	3,123	3,546
Low estimate	1,907	2,352	1,936
Other non-industrial uses	2,109	2,960*	3,459

*Pertains to 1990.

It has been reported that the livestock population of pre-1947 India increased by 46 percent between 1912 and 1935 (Whyte, 1964). There were over 292 million livestock (excluding poultry) in India in 1951, over 306 million in 1956, over 336 million in 1961, over 344 million in 1966 and over 353 million in 1972 (Anonymous, 1975). There has therefore, been a steady increase in the livestock population of the country, the increase being of the order of 20.7 percent during the period 1951-1972. Over 10 percent of this population is dependent on forest grazing (M.O.A., 1974) most of the accessible forest areas being heavily grazed. Due to difficulty of ensuring sustained scientific range management, these areas provide poor quality pasture.

In addition to meeting the ever expanding requirements of wood and grazing, forest management in India faces greatly increased demands for other products and services which the forests provide. Much of the forest in the country is situated in the sensitive catchment areas of many important rivers and maintenance of a forest cover in these catchments is necessary to protect water quality and regulate streamflow to control floods which have become an annual feature. Protection alone will not however, produce the large increases of water greatly needed by the growing population, agriculture and industry as indicated in Table 6 (Nag and Kathpalia, 1975). The requirements of fresh water in the country are expected to double during the next 20 years. These sensitive catchments have therefore, to be managed for increased water yield through manipulations of forest cover, flood control, and water quality.

Table 6. Requirement of fresh water

	1974	2000	2025
	(Million ha m)		
Irrigation	35.0	63.0	77.0
Domestic and livestock	1.3	3.4	5.0
Industries	0.5	3.0	12.0
Thermal power	1.0	6.0	16.0
Total	37.8	75.4	110.0

With industrialisation and creation of employment opportunities in cities, there has been a continuous influx of population into urban environments, for the last few decades. The urban population of the country was of the order of 79.60 million in 1961 which rose to 110 million in 1971 and is expected to touch 410 million in the year 2000 (Table 3). Urbanisation, population growth and industrial progress coupled with the rising standards of urban population and tensions created by the congested city life has resulted in increasing demands for recreational needs. Most of the country's urban locations are congested and exposed to various forms of pollution (air, water, noise, etc.) which reduces the scope for improving the quality of life in the cities. It has been found that the suspended particulate matter in Indian cities is much higher as compared to that of cities in western

countries. One hour carbon monoxide concentration in Calcutta has been found to be as high as 35 ppm during traffic hours. It is known that very large amounts of sulpher dioxide are emitted from industries and other sources like burning fuels. With a consumption of 70 million tonnes of coal in 1970, the emission of sulpher dioxide was estimated to be of the order of 6,800,000 tonnes per year, in addition to other organics and particulates (Anonymous, 1978). While small blocks of forests and tree groves close to cities could serve as recreation centres for urban population, the major brunt of recreation would come on forest lands which will have to be managed for this use also.

India is gifted with a very rich and varied fauna due to the diversity in her physical features revealing itself in corresponding differences in the types of forest and the variety of wildlife, which can live in such physically complex areas. Thus various regions of the country produce a variety of physical and biological conditions which favour the distribution of a variety of wildlife each adapted to a particular ecological zone which alone will favour its growth. This use is increasing and with a shrinking resource base there is a decrease in wildlife population thereby causing a greater pressure on our forest areas for an integrated forest and wildlife management approach to provide the necessary habitats for our varied and dwindling wildlife.

Shifting cultivation or Jhumming (a legacy from the neolithic period) practised in about 16 states of the country, has very deep roots and very wide ramifications, as the tribal group system of cultural and ethnic mores is typical of the area and has resisted change for a very long time. It is rooted in the cultural ethos of the tribal societies, and although their traditional economy has evolved to some extent, the constraints imposed by the environment and the mounting population combined with the shrinking resources, have inevitably led to short-term adaptations, with possibilities of disaster in the long run. Adequate data about the extent of land affected by shifting cultivation are not available, in the absence of any regular surveys and transitory nature of the practice, except for very rough estimates mostly based on small samples and intelligent guess work. The earlier estimate (1956) places the total area involved at 0.542 million ha and the number of tribal families affected at 528,940, with a population of 2.64 million (Kaith, 1958), or a mean family size of 5. The later estimates conclude that 2.589 million tribals depend on shifting cultivation extended annually over an area of 0.541 million ha. The extent of this practice in the Northeastern region of the country is indicated in Table 7 (N.C.A., 1976) which shows that the total area affected by the shifting cultivation is 2.696 million ha or approximately six times the annual area. This implies a disturbing shortening of the Jhum cycle to 6 years only. However, locally, the cycle may be as short as 2-3 years, which precludes the necessary flexibility to allow the natural processes of recuperation to repair these damaged ecosystems. It is now accepted that this alarming practice has to be rationalised and integrated in our management systems apart from other social and economic measures that need to be taken for the uplift of the tribal population.

Table 7. Extent of shifting cultivation in Northeastern region

(1) Total area affected by shifting cultivation (million ha)	2.696
(2) Area under shifting cultivation at a point of time (million ha)	0.456
(3) S. No. (2) as % of (1)	16.8
(4) Total families involved (000)	492
(5) Area cultivated per tribal family (ha)	0.92

In the context of what has been mentioned so far, the management of our forest lands to serve as many uses as possible is imperative and becoming more essential. When there were too few people and abundance of forest resources there was little need for multiple use. But with growing population with static, in fact diminishing, resource base we have to make the most effective use of the resources we have. Multiple use of forest lands is thus a necessity born out of resource scarcity and growing population who need these resources, in order to satisfy the tangible and intangible needs of the society.

ENVIRONMENTAL IMPACTS

It is pertinent to point out here that so far forest management in India has been, by and large, conservation oriented with emphasis on a single use of wood production. However, while the management of our forests had a unidirectional emphasis, their other uses (grazing, water, wildlife) were also given due consideration in the working of these forests. In fact, while many forest areas on steeper slopes of river catchments were protected and managed for water yield, flood control and soil conservation and water quality, food production in conjunction with forest crops (agri-silviculture) in other forest areas in different parts of the country has been practised for long. But there has been no attempt in the past towards optimisation of uses (multiple-use) from our forest lands as such. There could be two basic reasons for this. Firstly, there were fewer people and lesser demands of the society on our forests and as such comparatively there was resource abundance. Secondly, conservation oriented policy of forest management

probably maintained a balance of needs and resources in the context of fewer people and lesser demands.

As a consequence, research on multiple use of forest lands to provide a basis for accomodating more than one use in our forest areas, has also lagged behind. There is thus extreme lack of data on the impacts of multiple use in general and much less on environmental impacts of a combination of forest land uses in particular. While considerable research work on the environmental effects of forest lands has been going on in the country during the last two decades or so, almost all these studies have been carried out under conditions of one forest land use - wood production - and not under two or multiplicity of uses for reasons just mentioned. The results of these studies have been comprehensively reported recently (Seth, 1978; Ghosh, Kaul and Rao, 1980) and the more important and relevant results are briefly reviewed hereafter.

It is well known that forests exert a profound influence on land, air and water but their effect is essentially at the micro level. It is only the integration of these micro influences over large areas and over long periods of time which result in macro effects on the environment as a whole.

Air and water are affected through the climatic influence, because the presence of forest cover modifies the climate markedly, on a micro level and to a greater extent on the macro level, as the total effect is greater than the sum of the parts. The intensity of solar radiation falling on the forest is markedly reduced, and this reduction leads to a modification of temperature and humidity, their vertical gradients, and the soil moisture regime, which, in turn, reacts on the nature, density and structure of the vegetation itself. The air temperature regime is made more equable through the reduction of the maxima and increasing the minima. The zone of minimum temperature does not lie at the bottom, but at a height of about 1.5 m (Table 8; Krishnaswamy, Dabral and Nath, 1957) and the temperature of the air inside a forest is lower than that prevailing higher up, contrary to what happens in the open where the adiabatic lapse rate is higher, resulting in a steeper temperature gradient in the lower layers of the atmosphere. Similarly, the range of the soil temperature is more equable both diurnally and seasonally. It also decreases with the depth of the soil, the main effective zone being up to 30 cm below the soil surface. As the inversion of temperature does not occur readily, the severity of frosts is reduced in as much that no frosts may be observed in winter inside a forest.

Table 8. Mean temperature (^{o}C) from January 11-15, 1954 at 3 hourly intervals for 24 hours

		Hours of the day							
		0800	1100	1400	1700	2000	2300	0200	0500
1.52 m above ground	Open	6.3	18.1	15.6	13.6	7.0	6.3	5.0	4.3
	Plantation	6.0	13.9	15.0	13.4	7.4	6.6	5.3	4.4
Ground level	Open	6.6	20.2	14.9	12.4	7.4	7.2	5.7	4.8
	Plantation	6.8	10.1	11.3	11.3	8.2	8.1	7.3	6.4

Humidity is higher in forest areas, being highest at the ground level at sunrise and as the temperature rises, the gradual fall in humidity leads to the transfer of water vapour from the ground by the evening. Dew formation is affected, being more in the open, and so are fog and mist which arise from radiation and advection. This is a source of occult moisture directly absorbed by the leaves. Moisture evaporates less readily, although evapotranspiration may deplete the soil moisture to a greater extent and to a greater depth, the effect varying with the soil-moisture regime as well as with the structure of the forest.

The velocity of wind is markedly affected, a fact utilized to advantage in the creation of shelterbelts and windbreaks. Soil-blowing and wind erosion are controlled, the wind-induced evaporation is diminished and the vegetation not only acts as a filter and cleanser, especially with respect to solid particles (dust, coal, ash, etc.) but also to polluting fumes and vapours. The efficiency is directly proportional to the physical structure, but the species also contributes to some extent. Some species are also much more resistant to damage from noxious fumes and thus perform better and longer. The role of vegetation as a producer and replenisher of oxygen needs hardly any emphasis, as virtually all life depends upon the oxygen layer produced and maintained through the functioning of the chlorophyll mechanism.

Forest canopy intercepts precipitation, a proportion of which evaporates directly from above. As the effect depends on the character of precipitation as well as on the nature and stratification of vegetation, all variations occur - from total inability of precipitation to reach the ground to only about a fraction being intercepted. A small proportion evaporates from the leaves and the balance reached the base

as stemflow. Both the water falling through the leaves and along the stem carry down mineral leachates, which may at times be substantial. A summary of all the studies undertaken on interception losses by different species (ages and densities) is given in Table 9 (Ghosh, Kaul and Rao, 1980). It is thus observed that interception by tree cover

Table 9. Interception by forest cover

Species	Percent of rainfall	
	Throughfall and stem-flow	Inter-ception
Acacia catechu	71.5	28.5
Alstonia scholaris	74.0	26.0
Eucalyptus hybrid[1]	88.44	11.56
Pinus roxburghii	77.9	22.1
Shorea robusta	74.7 61.8	25.3 38.2
Tectona grandis	79.2	20.8

[1] Eucalyptus hybrid is now believed to be E. tereticornis.

varies from 12 to 38 percent. On the average it can be assumed to be around 20 percent of the rainfall (Seth, 1978). Though no detailed studies have been carried out on interception by the ground vegetation, it is estimated to be at least 10 percent on a conservative basis. Interception by leaf litter could be of the order of 5 percent of the gross rainfall. Thus, over 35 percent of rainfall is intercepted by the forest cover. In areas of high rainfall, this reduction assumes greater importance as there will also be a proportionate reduction in runoff. On the other hand, in areas of low rainfall, water yield calculations should take the forest cover also into consideration for a proper and reliable assessment. On per ha basis (kg/ha) the contribution of nutrients through stemflow and throughfall (excluding rain water) to the soil in case of Eucalyptus hybrid is: N, 2.2; P, 0.2; K, 13.3; Ca, 12.6 and Mg, 2.2 (age 6 years and density 1,658 trees/ha) while the input of various nutrients by rain is: N, 1.7; P, 0.2; K, 5.2; Ca, 5.9 and Mg, 2.5.

One of the most important functions of forest consists in conditioning the soil to permit it to act as a reservoir for water. The optimum infiltration rates permit recharging of the permanent underground aquifers, regulate flow of surplus seepage and hold an enormous quantity in temporary and permanent storage in the solum which is much less prone to evaporation and is available over the seasons for plant growth. The forest floor consists of a large amount of decomposing organic matter which changes the physico-chemical properties of the soil. Infiltration rates have been observed to be higher under forest as compared to other types of land use as indicated in Table 10. Studies to determine the effect of

Table 10. Average hourly infiltration rates

Land use	Infiltration rates (cm/hr)		
	1st hr.	2nd hr.	3rd hr.
Cultivated valley area	3.70	1.94	1.91
Forest area in foot hills	5.87	3.78	3.83

different land uses on the infiltration rate of black cotton soils have shown that maximum infiltration rate (0.20 cm/hour) was under forest cover. Infiltration studies carried out under dry run conditions gave 5.16 cm per hour under forest, 5.30 cm per hour under mixed plantations of Eucalyptus globulus and wattle, 3.00 cm per hour under natural grassland and only 1.40 cm per hour under terraced cultivation.

Data on soil moisture changes (soil moisture regime) for forest ecosystem in India is extremely lacking, much less under different forest land uses, though the same have been computed for a few areas as per different formulae. Studies carried out in West Bengal under three cover conditions, viz., (a) coppic sal (Shorea robusta) forest protected against fire and grazing, (b) coppice sal continuously cut-back and finally converted into scrub, and (c) barren waste land, have shown that the bushy sal forest retained maximum soil moisture and the barren land the minimum. Also the bushy sal forest and the standing sal coppice forest retained more soil moisture in comparison to barren waste land.

The probable water loss through evapotranspiration of a dry deciduous forest (18,650 sq km) in the catchment of river Damodar has been estimated at 560 mm per year or about 49 percent of total precipitation. On the basis of one year's studies made at Dehra Dun (rainfall 2,400 mm) up to a soil depth of 1.22 m rather rough estimates of evapotranspiration losses from plantations of Pinus roxburghii (25 years), Tectona grandis (35 years) and Shorea robusta (37 years) have been reported. These losses for one year amount to 840, 840 and 560 mm respectively for the three species. There are many difficulties in arriving at the annual water consumption of a forest ecosystem. The approximate water consumption of a Shorea robusta stand as computed by Champion and Seth (1968) is shown in Table 11. Preliminary studies carried out in minilysimeters to determine the potential water consumption of Dalbergia latifolia, Eucalyptus citriodora, Pinus roxburghii and Populus casale (488) seedlings have indicated the results shown in Table 12.

Table 11. Water consumption by Shorea robusta

Age of the crop (yrs.)	37
No. of trees/ha	778
Average D.B.H. (cm)	23.9
Average height (m)	24.4
Average daily transpiration (litres/ha)	38,000 (or 3.3 mm)
Average yearly transpiration (mm)	1,200
Transpiration per average tree	
Per year (litres)	15,500
Per day (litres)	42.4

Table 12. Potential water consumption

Species	Potential water consumption (mm)	
	Per seedling	Per g of dry matter produced
Dalbergia latifolia	1,143	2.59
Eucalyptus citriodora	5,526	1.41
Pinus roxburghii	936	8.87
Populus casale (488)	2,704	3.04

Forests smoothen the water-flow mechanism and reduce surface and subsurface run-off markedly, with enormous effects on the intensity of floods as well as on soil wash. In short, the effects on the land are perhaps more important in that land degradation is reduced to the minimum and this condition, compounded with controlled stream-flow, emphasizes the importance of forests as the most efficient means of soil and water management, especially in areas where other methods of conserving soil and water are not feasible owing to high cost and the present stage of technological development.

Hydrological studies carried out in watersheds of hill Shorea robusta forest (moist decidious forest) near Dehra Dun have indicated that average runoff was about 42 percent of the total rainfall, the total sediment discharge during the monsoon months ranged from 49 to 153 tonnes per sq km and the water flowing out was of high purity tending to be acidic. Seventeen watersheds having different land uses gauged in the Ootacamund hills have shown that the watershed which has 99.5 percent area under Eucalyptus and wattle plantations gave a maximum discharge of 41.1 cusecs and the watershed having 73.9 percent area under forest plantation gave peak discharge of 53.3 cusecs. Watersheds having 83.9 and 77.7 percent area under agriculture gave 143 and 145 cusecs peak discharge respectively (Table 13). Data on peak discharge computed for selected storms of some agricultural

Table 13. Peak discharge from watersheds under different covers

Cover condition	Area (%)	Peak discharge (cusecs)
Eucalyptus and wattle	99.5	41.1
Eucalyptus and wattle	73.9	53.3
Agriculture	83.9	143.0
Agriculture	77.7	145.0

and forest (Shorea robusta) watersheds at Dehra Dun (moist deciduous forest) have shown that forest watershed had lower peak discharge that the agricultural watershed by about 10 percent. The agricultural watersheds recorded significantly high soil loss per ha as compared to the watershed under mixed land use (agriculture and forest) and under forest. The watershed under forest gave about 38.5 percent less soil loss than agricultural watersheds.

Forest ecosystems contribute a lot of organic matter to the soil in the shape of leaf fall, twigs, branches, fruits, etc. which influence soil properties in many ways apart from being source of nutrients to the plants, the nature and amount of this contribution depending, besides other factors, on the species present. The data for litter fall in a typical tropical deciduous forest dominated by Shorea robusta computed from various sources show that the annual litter fall is of the order of around 7,000 kg per ha of which leaves contribute nearly 5,000 kg, the balance being made up by other litter components. On the basis of this data the annual return of nutrients through litter fall as kg per ha is: N, 56; P, 14 and K, 42 (Misra, 1969). However, the rate of decomposition of litter and release of nutrients is almost unknown in our forests though it has been estimated that the time required for leaf litter of tropical deciduous forest to decompose may vary from 3 to 15 months (Misra, 1968).

Man-man Forests

While the existing naturally regenerated forests of the country will continue to provide wood raw material, natural regeneration systems cannot adequately cope up with rising demands of wood (Table 5) because of many limitations. There are also vast areas of other miscellaneous forests of low value where any management could yield practically very little unless aided intensively artificially. The obvious answer lies, besides other means of increasing production, in raising plantations of suitable species, i.e., replacement of these low value forests by simplified ecosystems of monocultures or mixed plantations. In the context of increasing productivity from our forest areas, spectacular gains have been achieved in the production of wood when tree species of natural forests are grown in plantations. The maximum increment (M.A.I.) attained by some of the

indigenous species when raised in plantations are shown in Table 14, though very often an introduced exotic is capable of producing much larger yields than indigenous species (Seth, 1971; Ghosh and Lohani, 1972) as also indicated in the same table.

Table 14. Maximum increment of species

Species	Age (yrs.)	M.A.I. (m^3/ha)
Indigenous species		
Cedrus deodara	70	13.92
Gmelina arborea	13	14.81
Michelia champaca	27	6.3
Pinus roxburghii	38	12.25
Pinus wallichiana	60	17.01
Shorea robusta	40	12.00
Tectona grandis	10	12.00
Toona ciliata	15	14.93
Trewia nudiflora	11	15.54
Exotic species		
Cryptomeria japonica	32	42.92
Eucalyptus globulus	10	50.00
Eucalyptus grandis	10	40.00
Eucalyptus tereticornis	8	22.00
Pinus elliottii	34	16.00
Pinus patula	30	34.95

This has led to the adoption of artificial regeneration practices and large areas supporting an inferior natural crop have been replaced by pure and mixed plantations of species of superior value. Plantations have so far been raised over an area of 2.1 million ha (Table 1) and it was proposed to raise further platations over an area of 2.47 million ha during 1974-1979 (M.O.A., 1974); the main species generally raised in the plantations being: Tectona grandis, Shorea robusta, Dalbergia sissoo, Eucalyptus grandis, E. globulus, E. hybrid, bamboo, Casuarina, Bombax ceiba, Acacia nilotica, A. catechu, A. tortilis, wattles, cashewnut, rubber, other fuelwoods, Cryptomeria japonica, Cedrus deodara, Abies pindrow, Picea smithiana, etc.

Artificial regeneration is practised all over India but is mainly restricted to the moist deciduous forests for purposes of production forestry where these plantations are economically viable. Plantations are also raised under social forestry programmes (village lands, roadsides, canal banks) and in other area, for example in arid and semi-arid zones, river catchments, coastal sands and other degraded areas. Here any work of afforestation or other soil conservation measures has been more protective in nature while tangible economic gains have been rather secondary, apart from meeting the immediate needs of the local population, the labour intensive aspects of these plantations and generation of greater economic activity in these areas.

Four distinct types of plantation techniques are adopted, namely, (i) clear felling an area and planting the same, (ii) clear felling an area and raising a plantation crop under Taungya (agri-silviculture) system which is very common for raising plantations of Shorea robusta, the system having also led to the introduction of foreign exotics and non-indigenous species in these areas, e.g., Eucalyptus hybrid in Uttar Pradesh and E. globulus in Tamil Nadu, (iii) enrichment planting, and (iv) planting for environmental amelioration, and rehabilitation of degraded areas.

With regard to the species raised in these simplified ecosystems there have been three types of introductions, namely, (i) raising the same species (which already existed in an area but in very small proportion) after clear felling, e.g., Tectona grandis in moist mixed deciduous forests, (ii) planting an area with a non-indigenous species as for example extensive planting of Tectona grandis outside its natural habitat as also Casuarina equisetifolia, and (iii) planting of exotics like Eucalyptus, Acacia, Cryptomeria japonica, etc. In fact large scale Tectona grandis plantations in the country would not have been possible without resorting to artificial means.

The moist deciduous forests would be the core of plantation activity for various reasons (including ease of planting and favourable site factors) and large areas of these forests would be converted into monocultures and mixed plantations of industrial importance (panel products, matchwood, pulpwood, etc.) except for areas where a species is gregarious and regenerates easily. In areas where a species is not gregarious and there is a definite problem of regeneration (Shorea robusta), there would be a definite tendency to convert these areas into plantations of more economically valuable species like Tectona grandis, Eucalyptus, tropical pines, etc. which can be easily raised.

What the long term effects of these forest land uses on various environmental parameters would be, are hard to predict, more especially in the tropical evergreen, semi-evergreen and high level coniferous types, due to lack of experience in this country, though speaking very broadly there will be significantly floristic and ecological changes which could be to the detriment of these ecosystems unless proper safeguards are taken.

It has been observed that yields in subsequent rotations of Casuarina equisetifolia (grown on coastal sands which are poor in nutrients with excessive permeability to water) in the same area drop gradually, perhaps due to site deterioration, and this is exemplified by the data presented in Table 15 (Rao, 1967). Similar observations of

Table 15. Yield of Casuarina

Rotation	Yield (tonnes/ha)
I	185
II	155
III	140

drop in yield of Eucalyptus globulus in successive coppice rotations have been indicated (Jayraman, 1974). As a general rule, the yield in the second rotation appears to be slightly higher (6 to 10 percent) than in the first one, but there is a fall in yield in the third (9 percent) and fourth (20 percent) rotations. While this drop in yield could be attributed to stump vigour to produce coppice shoots, the possibility of site deterioration cannot be ruled out. Reduction in yield has also been noticed in Quality III crops of Tectona grandis plantations in Nilambur in the second rotation (Prakash and Khanna, 1979).

Studies on organic productivity and nutrient cycling in a number of Eucalyptus hybrid plantations (George, 1977) have given some interesting results. Interception studies in one plantation (age 6 years; density 1,658 trees/ha) have shown that the total stemflow and throughfall accounted for 7.69 and 80.75 percent of the total rainfall respectively, while only 11.56 percent of the total rainfall was intercepted by the canopy (Table 9). The interception loss is low as compared to indigenous species like Shorea robusta (25.3 percent), Alstonia scholaris (26.0 percent) and Pinus roxburghii (22.1 percent) with somewhat comparable densities. Thus the rainfall availability to the soil through Eucalyptus plantation is more than some of the indigenous species.

Nutrient circultation and annual and rotational budgets prepared for one plantation felled at 10 years age (1,133 trees/ha) have given the results indicated in Table 16. It will be seen that of the total uptake of various nutrients 81, 64, 92, 101, and 90 percent of N, P, K, Ca and Mg, respectively are returned to the soil through the biological cycle, and rain water. These figures, however, do not include inputs through the geochemical cycle

Table 16. Nutrient budget of a Eucalyptus hybrid plantation (Density 1,133 trees/ha; Rotation 10 years)

	Nutrients (kg/ha)				
	N	P	K	Ca	Mg
Total uptake in 10 yrs.	801	129	648	2192	221
Total return in 10 yrs.	650	81	596	2204	198
Total return as % of uptake	81	64	92	101	90

which are difficult to monitor, nor has the role of understorey vegetation in nutrient circulation been studied. It will thus be observed that the highest drain of nutrients in Eucalyptus hybrid seems to be in the case of N and P, other nutrients being returned in almost the same amounts as their uptake. While obviously a fast growing species like Eucalyptus which has a higher production in a shorter time would drain the soil more than a climax forest, the results of these studies are a definite pointer that some safeguards in terms of fertilization etc. are necessary in the management of these plantations. Management practices have, therefore, to be so adjusted as to leave all possible tree components on the soil at the time of harvesting besides addition of nitrogenous and phosphatic fertilizers to maintain the fertility status of the soil, specially on nutrient poor sites.

The controversy that has gained ground of late, is about the possible adverse effects of Eucalyptus planting on local water supply specially in Nilgiri hills of South India. This probably has its origin from the fact that certain species of eucalypts were planted in the 'Pontine Marshes' near Rome for reclaiming these marshes in the 18th century. Though there is no experimental evidence in this country to prove or disprove this claim, the situation should not be so alarming as presented. The annual transpiration rate of Eucalyptus globulus in the Nilgiris (South India) has been reported to be about 3,475 tonnes/ha which corresponds to 34.75 cm of rainfall only. Thus out of the 130 cm of rainfall received in this area, about 95.25 cm are still available for interception loss, run-off, evaporation, deep percolation, water yield and soil moisture storage. Therefore, the criticism that planting of watersheds in the Nilgiris by blue gum has an adverse effect on water yield, appears to be rather exaggerated. Of course, the treatment of watersheds in full or part, can be scientifically planned, depending on the requirement of water yield from the catchment and the community needs. Ghosh, Kaul and Rao (1978) have made a brief survey of the information available on the effects of Eucalyptus plantations with particular reference to water relations and soil nutrition and have observed that reports regarding the adverse effects of Eucalyptus plantations on water supply are rather exaggerated.

Fears have also been expressed that wildlife habitats are being destroyed for raising large scale plantations of fast growing monocultures, (Eucalyptus) causing a further decrease in our already dwindling wildlife population. In this regard the allelopathic influences of Eucalyptus on indigenous vegetation need mention. While monocultures by their very nature are not conducive to varied fauna, suitable safeguards will have to be taken to see that the interests of wildlife are protected, which leads us to an integrated approach for forest and wildlife management.

Though *Taungya* (agri-silviculture) system of growing forest plantations has been going on for a long time in this country, its possible environmental impacts have never been studied though the system seems to be more beneficial than harmful in that it is still in vogue and recommended as an alternative to shifting cultivation. Very preliminary studies carried out on the environmental effects of agri-silviculture at Ranchi, where *Tectona grandis* and *Dalbergia sissoo* were raised in conjunction with food crops (paddy, maize, millet) and oil seeds like groundnut, have shown no site deterioration but on the other hand there seems to be an overall improvement in the soil nutrient status (Mishra, 1980). There is an urgent need for extensive research on the subject.

Mining

India is bestowed with a rich variety of minerals which play an important role in our industrial and economic development. The extent of area under mining leases in the country in 1973 was of the order of 683,672 ha (Mathur, 1978) spread over 19 states. Minerals are exploited either by reaching them through shafts or by removing the overburden, causing serious environmental degradation. The environmental impacts due to these mining processes include loss of production (forest, agriculture, pasture) loss of top soil, surface water pollution, lowering of ground water tables, hazards of ore transport (damage to vegetation, soil, drainage, agriculture, water quality and property), sediment production and discharge, fire hazards (coal mine producing injurious gases) and air pollution. Considering the need to exploit the mineral resources and at the same time the importance of environmental conservation, it is imparative that our mineral resources are exploited in a manner which will cause the least amount of environmental degradation and that the mined areas are rehabilitated. This could be achieved by adopting suitable conservation techniques right through the processes of mine survey, planning, development and abandonment, and excluding mining from vulnerable areas. Research is urgently needed on reclamation, rehabilitation and afforestation of these mine spoils.

CONCLUSION

From the foregoing it is clear that multiple use research has not received the attention it deserves in India in the context of the present day needs of the rising population, and consequent strain on our shrinking forest resources and whatever little has been done is rather fragmentary and of recent origin. Production forestry goals have rather outweighed in our management strategies so as not to get multiple use research well established.

Having accepted that multiple use of forest lands is a necessity of the modern times, the impact of multiple use on forest environment both under conventional and man-made ecosystems including agro-forestry systems is of greater relevance. As such three distinct research approaches have to be followed, namely (i) environmental impacts of multiple use of natural forest lands, (ii) environmental impacts of plantations including agro-forestry systems, and (iii) rehabilitiation of degraded ecosystems for multiple use.

It is necessary to evaluate the existing conditions, present uses and ecological changes taking place in the tropical forests including trends in utilisation of tropical forest lands and present uses of tropical products.

The impact of multiplicity of uses on the production and fertility of tropical forest ecosystems needs investigation. This would include studies on biological productivity and cycles and budgets of minerals and materials critical to productivity and stability in natural undisturbed, partially disturbed and man-made ecosystems; impacts of these uses on soil structure, nutrient retention, regeneration capacity, runoff, water yield, microclimate, wildlife and subsequent land use opportunities, and long range effects of different forestry and agricutural land uses including clear felling, partial felling, shifting cultivation, grazing, and monocultures. The effects of loss of biological diversity in the wet tropics need to be studied, as high diversity has been commonly associated with high stability and high resistance to disturbance such as caused by entry of disease organisms and extreme fluctuations of climatic parameters. Compatibility of resource uses need to be investigated as also the rehabilitation of degraded ecosystems for multiple use.

The effects of manipulations of tropical forests on the sociocultural and behavioural characteristics of human population living there need to be studied, as also the demographic changes that are taking place and the relations between these changes and the manipulation of forest areas for different uses. This would also involve studies on the immigration of population into altered tropical environments as well as emigration of population as a result of deterioration of the habitat.

Within the various research approaches mentioned earlier, simulation, optimisation and prediction models may be developed as an integral part of the work plan. These models could be used in devising procedures for minimising degradation and optimising uses from our forest lands. They would also provide a new direction for forestry to systematically provide multiple benefits.

The concept of multiple use presents new challenges and new opportunities to foresters everywhere, with great prospects for additional services to the welfare of mankind though it is not a solution to all forest management problems. Often one use has to be dominant and other proposed uses must not then be detrimental to the

major one. Moreover, there can be disadvantages to multiple use when applied inefficiently. But multiple use has to be recognized as a goal of all forest policies and management strategies in the context of present day needs of the growing population and consequent strain on the shrinking forest resources all over the world. This brings us to the concept of 'forests for the people' and as Steenberg in his keynote address to the Seventh World Forestry Congress noted: "Whatever the total complex of reasons for the present situation, the important thing is to grasp the true significance of this historic opportunity for forestry: the current resonance between the ideals of the small enlightened group of renewable-resource managers and society at large."

SUMMARY

This paper briefly describes Indian forests, which occupy nearly 75 million ha (22.8 percent) of the total land area of the country. These forests are divided into 16 type-groups ranging from Tropical Wet Evergreen Forests to Alpine types; the Tropical Deciduous types (both moist and dry) constituting the bulk (70 percent) of the forests. The reasons for multiple use of these forests are discussed, and it is mentioned that multiple use of these forests is a necessity born out of growing population with resultant resource scarcity, increasing demands for raw material and other goods and services that these forests provide, and shifting cultivation. The results of research work carried out in India on the impact of various forest land uses on different environmental parameters with regard to natural and man-made forests are briefly discussed. It is brought out that there is an extreme lack of data on the impact of multiple use in general, and much less on environmental impacts of a combination of forest land uses in particular. Future research needs include three distinct approaches: (1) environmental impacts of multiple uses of natural forests, (2) environmental impacts of plantations including agro-foresty systems, and (3)rehabilitation of degraded ecosystems for multiple use.

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EL IMPACTO DEL USO DE LAS TIERRAS FORESTALES EN EL MEDIO AMBIENTE EN LA INDIA

Este informe describe brevemente los bosques de la India que ocupan casi 75 millones ha. (22.8 por ciento) del área total del terreno del país. Estos bosques están divididos en 16 tipos de grupos que varían desde bosques de follaje permanente tropicales húmedos a bosques alpinos; los tipos caducifolios tropicales (los dos húmedos y secos) constituyen la mayoría (70 por ciento) de los bosques. Las razones para el aprovechamiento múltiple de estos bosques son mencionadas, y se menciona también que el aprovechamiento múltiple de estos bosques es una necesidad, la que nació de la demanda de una población que crece continuamente, la que resulta en la escasez de los recursos, aumentando la demanda para materia prima y otros géneros y servicios que estos bosques proveen, y rotaciones de cosechas. Los resultados de estas investigaciones realizadas en la India sobre el impacto de varios aprovechamientos de terrenos forestales sobre diferentes parámetros ambientales relativos a bosques naturales y hechos por el hombre son discutidos brevemente. Se demuestra que hay una falta extrema de datos sobre el impacto del aprovechamiento múltiple en general, y mucho menos sobre impactos ambientales de una combinación de aprovechamientos de terrenos forestales en particular. Las necesidades de investigaciones en el futuro deben enfocarse hacia tres áreas: (1) impactos ambientales del aprovechamiento múltiple de bosques naturales, impactos ambientales de plantaciones que incluyen sistemas agro-dasonómicos, y (3) rehabilitación de ecosistemas degradados para el aprovechamiento múltiple.

EINFLUSS DER NUTZUNGEN VON FORSTLANDERN AUF DIE UMWELT IN INDIEN

Dieser Bericht beschreibt in Kürze die indischen Forsten, die beinahe 75 Millionen Hektar (22.8 Prozent) der Gesamtfläche des Landes einnehmen. Diese Forste sind in 16 Typ-Gruppen eingeteilt, die von den tropischen, feuchten, immergrünen Wäldern bis in die alpinen Typen reichen; die tropischen Laubwaldtypen (feucht und trocken) machen den Hauptbestandteil (70 Prozent) aller Forsten aus. Die Gründe für die vielseitige Nutzung dieser Wälder ist besprochen, und es wird berichtet, dass die vielfältige Forstnutzung notwendig ist wegen einer wachsenden Bevölkerung, die einen Mangel der Naturschätze mit sich führt, eine wachsende Nachfrage nach Rohprodukten, anderen Erzeugnissen und Diensten die diese Wälder und "shifting cultivation" bereitstellen. Die Ergebnisse von Untersuchungen des Einflusses von verschiedenen Forstnutzungen in Indien auf verschiedene Umweltsfaktoren, bezüglich natürlicher und angepflanzter Wälder, werden kurz besprochen. Es wird bewiesen, dass ein starker Mangel von Daten besteht, die sich auf den Einfluss der vielseitigen Nutzung im allgemeinen beziehen. Noch weniger Daten sind vorhanden, die sich mit dem Umwelteinfluss einer Kombination von Forstnutzungen im besonderen befassen. Zukünftige Untersuchungen sollten drei bestimmte Richtungen haben: (1) Umwelteinflüsse vielseitiger Forstnutzung, (2) Umwelteinflüsse von Pflanzungen einschliesslich von Agrar-Forstwirtschaftssystemen, und (3) Wiederherstellung von degradierten ökologischen Systemen, um sie einer vielseitigen Benutzung zuzuführen.

EFFET DE L'EXPLOITATION DES FORETS SUR L'ENVIRONNEMENT AUX INDES

Cette étude décrit brièvement les forêts des Indes qui occupent presque 75 millions d'hectares, soit 22,8% de la superficie du pays. Ces forêts se divisent en seize sortes, telles que les forêts tropicales humides toujours vertes, les forêts alpines et les forêts tropicales à feuillage caduc, soit humides soit sèches, qui constituent la plus grande partie (70%) des forêts. Les raisons pour un usage multiple y sont données, et il est mentionné que c'est une nécessité causée 1) par la croissance de la population et le manque de ressources qui en résulte, 2) par le besoin en matières premières et en d'autres produits et services des forêts, et 3) par l'assolement. Cette étude traite brièvement des résultats des recherches faites aux Indes sur les effets des usages variés des forêts selon différents paramètres de l'environnement. Elle met en évidence un manque extrême d'informations sur l'effet de l'usage multiple en général et le manque encore plus grand d'informations sur les effets sur l'environnement d'une combinaison d'usages des forêts en particulier. Les recherches se feront dans l'avenir selon trois méthodes distinctes: 1) les effets sur l'environnement de l'usage multiple des forêts naturelles, 2) les effets sur l'environnement des plantations comprenant les systèmes d'agrosylviculture, et 3) la reconstruction des écosystèmes endommagés en vue d'un usage multiple.

Multiple-Use Forest Management by Goal Programming Input-Output Analysis[1]

Sun Joseph Chang[2]

Abstract.--The goal programming/input-output analysis model is proposed to provide a plausible solution to the problem of multiple use forest management. A hypothetical management problem is analyzed with this technique to determine the optimal allocation of scarce resources. In addition to parametric programming and specification sensitivity analysis, compatibility analysis and trade-off analysis are also performed to allow for the fine-tuning of management decisions.

INTRODUCTION

As society becomes more affluent, its use of forest resources also becomes more diverse. No longer is timber the dominant concern of forest management. A forest today is managed to provide society with fish and wildlife, outdoor recreation, forage, environmental amenities, water and timber (Alston 1972). Associated with the task of multiple use forest management, however, is the perennial problem of determining the value of management outputs. Many outputs, for example, hiking and cross-country skiing, completely escape the market place. Consequently, these outputs remained unpriced. For other management outputs, such as camping and picnicking, fees may be an inadequate indicator of true social value because of market imperfections. Forest managers, therefore, face the problems of allocating scarce resources for multiple use with either unavailable or inadequate price information.

This paper presents a goal programming/input-output analysis model (GP-IO model) (Chang 1979)[3] as a plausible solution to this problem. The GP-IO model combines input-output analysis and goal programming to provide forest managers with a tool to link society's demand for multiple use of forest resources with their planning of management activities.

LITERATURE REVIEW

Linear programming, a widely used operations research technique, has been applied to solve many forestry problems. (See Bare (1971) or Martin and Sendak (1973) for examples of applications.) With the objective function of linear programming limited to the maximization or minimization of one single objective, applications of this technique to multiple use forest management problems must first convert the benefit and cost of each activity into one common measurement unit, usually in terms of dollars. As indicated earlier, however, prices for the output of some management activities are inadequately priced, and not all costs can be converted into dollar figures. In one of the rare published applications of linear programming to multiple use forest management problems, Leuschner, Porter, Renolds and Burkhart (1975) attempted to bypass the difficulty of converting benefit and cost into dollar figures by maximizing one objective, timber harvest, subject to constraints imposed by scarce resources and other management outputs, such as hiking, camping, hunting, and fishing. This approach has several drawbacks. First, this approach renders other goals more important than timber production, since goals expressed as constraints must be satisfied before the objective function is maximized. Second, this approach assumes that the goals expressed as constraints are equally important. Finally, this approach has no solution if other goals expressed as constraints cannot be satisfied simultaneously.

Multiple use forest management, therefore, necessitates the adoption of some new techniques which are designed to handle multiple objective management problems. Among the techniques adopted is goal programming. Since Field (1973) introduced goal programming into the forestry literature, this technique has been applied to residue reduction (Bare and Anholt 1976), genetic improvement (Porterfield 1974), and timber production planning (Rustagi

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[3]Chang, S.J. 1979. Multiple objective planning at the Nicolet National Forest: a goal programming input-output analysis case study. Unpublished Ph.D. thesis, University of Wisconsin, Madison, Wisconsin. 177p.

1976). It has been applied to multiple use forest management by Chang (1975)[4], Schuler (1975), Schuler and Meadows (1975), and Schuler, Webster, and Meadows (1977), Bell (1975), and Dane, Meador, and White (1977). Despite differences in model formulation and solution algorithm, none of the work in multiple use forest management mentioned above takes into consideration the interdependent input-output relationships among management activities. Apparently, a multiple objective optimization technique which also incorporporates the interdependent input-output relationships of various activities is necessary to handle the multiple use management planning problem. Presented in the next section is one such model, the GP-IO model.

GOAL PROGRAMMING/INPUT-OUTPUT ANALYSIS

Goal Programming

Mathematically, a goal programming model takes the general form:

$$\begin{aligned} \text{Min. } Z &= UD^- + WD^+ \\ \text{S.T. } \quad TX + D^- - D^+ &= G \\ CX &\leq R \end{aligned} \qquad (1)$$

where U, W are 1 x m vectors of weighted and unweighted priority factor.

D^+, D^- are m x 1 vectors, representing respectively positive and negative deviations from goals.

T is an m x n matrix expressing the technical relationships between decision variables and goals.

G is an m x 1 vector of desired level of goal attainment.

C is a p x n matrix of technical relations between decision variables and scarce resources.

R is a P x 1 vector of scarce resource constraints.

The procedure for goal programming is to first specify the desired goals, and second find a solution that will approach the desired goals as closely as possible, subject to the constraints imposed by technical processes and resource scarcities. Each goal is quantified according to its own appropriate unit of measurement -- board feet of timber, visitor days of camping, etc.. Because the deviations that are minimized have different measurement units, priorities and weights are assigned to deviations to bring the optimization process in line with the preferences of the decision maker. Ordinal priorities are assigned to those goals whose relative importance cannot be measured by an exact number in order to establish an ordering of goals. Thus, for all objectives ranked j'th in importance, a positive numerical priority factor coefficient P_j is assigned. Similarly for objectives ranked (J+1) 'th in importance, P_{j+1} is assigned. The P_j and P_{j+1} must satisfy the relation $P_j > nP_{j+1}$ for all feasible n, no matter how large. The function of ordinal priorities in GP is to ensure that the most important goal is satisfied first, the second most important second, and so forth. Unless a goal with a higher priority is fully achieved or achieved to its utmost possible extent, no resource will be devoted to the achievement of goals with lower priorities. Cardinal weights, added as multipliers to the ordinal priority factors, are assigned to goals within the same priority to reflect their relative importance. Thus for two goals, A and B, within priority P_j, W_aP_j would be assigned to goal A and W_bP_j would be assigned to goal B such that W_a/W_b reflects their relative importance. The function of weights in GP is to ensure that within a particular priority level, goals with larger weights will be satisfied before those with smaller weights. Thus, suppose that a forest manager believes hiking is more important than timber harvesting, but cannot really measure how much more important it is by an exact number. Priority 1 (P_1) would then be assigned to his goal of, for instance, 10,000 hiker-days and priority 2 (P_2) to his goal of harvesting, for instance, 100,000 board feet of timber. Consequently, the goal programming model will not allocate any resources to timber harvesting until the goal of 10,000 hiker-days has been achieved or achieved to its utmost possible extent.

In addition, if the goal of harvesting 100,000 board feet of timber is further divided into harvesting 60,000 board feet of softwoods and 40,000 board feet of hardwoods, and hardwoods are 3 times more valuable than softwoods, then the forester could assign a weight of 3 to hardwoods production and a weight of 1 to softwoods production to reflect their relative importance.

Input-Output Analysis

When a forest is managed under the principle of multiple use to provide society with an array of outputs, the management problem for such a forest consists of determining how much of each product and service should be provided given a specific quantity of scarce resources.

Since management activities are often interdependent -- that management activities use the outputs of other management activities as their inputs, input-output tables provide a convenient way of describing this interdependency among management activities.

Mathematically, such a table can be expressed as

$$\begin{aligned} AX + F &= X \\ \text{or } (I-A)\,X &= F \end{aligned} \qquad (2)$$

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[4] Chang, S.J. 1975. A test of goal programming on the Kilkenny management unit. Unpublished M.F.S. thesis, Harvard University, Cambridge, Massachusetts. 96p.

where A is an n x n input-output technology matrix
F is an n x 1 vector of final demands
X is an n x 1 vector of total output,
and I is an n x n identity matrix.
A, F, and X are all expressed in physical units.

One way to solve the problem of multiple use forest management within the input-output analysis framework is to maximize the value of the final demand vector by linear programming as follows:

$$\text{Max } PF = P\,(I-A)X$$

$$\text{S.F. } CX \leq R \qquad (3)$$

where A, I, X and F are the same as defined earlier,
P is a 1 x n vector of prices for the output of various management activities.
C is a k x n matrix of technical relationships between output of various activities and scarce resources.
R is a k x 1 vector of available scarce resources.

If the market could establish a socially acceptable price for the output of each management activity on a forest, then the above approach would result in an optimal mix of products and services. Unfortunately, as pointed out earlier, many management outputs do not command a price. Because of market imperfections, the prices of other management outputs are not adequate indicators of true social value.

Goal Programming/Input-Output Analysis

Instead of maximizing the value of the final demand vector, in goal programming/input-output analysis, a desired level of final demands F is first established as the goals to replace the G vector. Then (I-A) matrix replaces T matrix to express the technical relationship between management activity and final demand. Thus, the goal programming/input-output analysis model attempts to approach the goals in final demand as closely as possible according to the priority and weight assigned to each final demand and subject to the scarce resource constraints.

Mathematically, such a model takes the form

$$\text{Min } Z = UD^- + WD^+$$

$$\text{S.T. } (I-A)X + D^- - D^+ = F$$

$$CX \leq R \qquad (4)$$

where A, I, F, X, C and R are as defined earlier in (2) and (3)
U, W are 1 x n vectors of weighted and unweighted priority factors.
D^+, D^- are n x 1 vectors, representing respectively positive and negative deviations from desired final demands (goals).

The next section presents the goal programming/input-output analysis of a hypothetical multiple use management problem.

Example

In this example, the hypothetic northern hardwood forest engages in 6 forest management activities. The name and desired goal for each management activity are presented below:

Activity 1: timber harvest, supervise 5335 acres of timber harvest.
Activity 2: timber sale preparation, prepare 6148 acres of timber sale.
Activity 3: merchantable stand management, maintain 129,070 acres of merchantable stand at the end of the year.
Activity 4: non-merchantable stand management, maintain 104,377 acres of non-merchantable stand at the end of the year.
Activity 5: camping management, provide 250.7 thousand visitor days of camping opportunities.
Activity 6: snowmobiling management, provide 90.4 thousand visitor days of snowmobiling opportunities.

Table 1 presents the goal programming/input-output analysis formulation of the hypothetical multiple use forest management problem with the priority assigned to each goal summarized in Table 2 under Run 1. The first six rows of the constraints represent the goals set for each management activity. Row 7 through row 12 represent the scarce resources the forest is facing. They include 127,955 acres of merchantable stand growing stock and 111,657 acres of non-merchantable stand growing stock which are available at the beginning of the year, 582 tent pads, 520 miles of snowmobile trails, 4863 man-days of labor and 277,764 budget dollars. The GP-IO model would first attempt to satisfy the goal of timber harvest by allocating scarce resources to minimize the negative deviation from the desired goal of 5335 acres. Once this goal is satisfied, the technique will then allocate scarce resources to satisfy goal priority 2, 3 and so on until scarce resources are exhausted. When the scarce resources are allocated according to the priority assigned to each goal as summarized in Table 2 Run 1, the first five goals are completely satisfied but the goal of priority 6--snowmobiling management is underachieved by 87.04 thousand visitor days.

Table 3 presents the level of resource utilization. It should be noticed that none of the forest resources are limiting factors in the achievement of the goal of snowmobiling. The limited budget available is preventing further achievement of the goal in snowmobiling management. At this point, the forest manager has many options. For example, Table 2 Run 2 shows the impact of rearranging the priority assigned to each goal. In this case, priority 4 is assigned to snowmobiling management while priority 5 and 6 are assigned to merchantable and non-merchantable stand management respectively. Such rearrangement of priorities

Table 1.--The goal programming/input-output analysis formulation of the hypothetical forest management problem.

$$\text{Min. } Z = P_1d_1^- + P_2d_5^- + P_3d_2^- + P_4d_3^- + P_5d_4^- + P_6d_6^-$$

S.T. $X_1 + d_1 - d_1^+$	=	5335	Acres Timber Harvest
$X_2 + d_2^- - d_2^+$	=	6148	Acres Timber Sale Prep.
$-X_1 + X_3 - .9274X_5 - 1.2611X_6 + d_3^- - d_3^+$	=	129070	Acres Merchantable Stand Management
$-.0522X_3 + X_4 - 1.0398X_6 + d_4^- - d_4^+$	=	104377	Acres Non-Merchantable Stand Management
$X_5 + d_5^- - d_5^+$	=	250.7	M.V.Ds. Camping
$X_6 + d_6^- - d_6^+$	=	90.4	M.V.Ds. Snowmobiling
$.9478X_3 + d_7^-$	=	127955	Acres Merchantable Stand
$X_4 + d_8^-$	=	111657	Acres Non Merchantable Stand
$1.7411X_5 + d_9^-$	=	582	Camp Sites Tent Pads
$2.3009X_6 + d_{10}^-$	=	520	miles Snowmobile Trails
$.0993X_1 + .3147X_2 + .0020X_3 + .0019X_4 + 7.5363X_5 + 6.3496X_6 + d_{11}^-$	=	4863	man-days Labor
$5.7316X_1 + 17.5942X_2 + .1129X_3 + .1069X_4 + 439.99X_5 + 476.1173X_6 + d_{12}^-$	=	277764	dollars Budget

Table 2.--Results of GP-IO analysis as goal priorities change.

		Run 1		Run 2	
Goal	Goal level	Goal priority ranking	Level achieved	Goal priority ranking	Level achieved
Timber harvest (acres)	5335	1	5335	1	5335
Timber sale Preparation (acres)	6148	3	6148	3	6148
Merchantable stand Management (acres)	129070	4	129070	5	0
Non-merchantable stand Management (acres)	104377	5	104377	6	0
Camping management (M.V.D.)	250.7	2	250.7	2	250.7
Snowmobiling management (M.V.D.)	90.4	6	3.36	4	60.30

Table 3.--Resource utilization analysis for Run 1.

Resource Description	Resource Available	Resource Not-Used
Stock of M. stand (acres)	127955.00	341.67
Stock of N-M. stand (acres)	111657.00	248.22
Camp sites (tent pad)	582.00	145.51
Snowmobile trails (miles)	520.00	512.26
Man-power (man-days)	4863.00	6.80
Budget (dollars)	277764.00	0

improves the goal achievement of snowmobiling management, but leaves both merchantable and non-merchantable stand management goals totally unsatisfied. Table 4 Run 2 shows the impact of increasing the available budget by 100 dollars while maintaining the original priority assignments. Such an increase in budget improves the achievement in snowmobiling from 3.36 to 3.57 thousand visitor days or a 210 visitor days increase. In addition to the above parametric sensitivity analysis, further post-optimal sensitivity analyses are available.

Compatibility Analysis

Once the optimal solution is reached, it is then possible to determine the compatibility among goals. For example, in the first case it is possible to determine the compatibility between goal priority 6 and the first 5 priorities once the optimal solution is reached. In order to examine the compatibility among goals, one has to look at the $Z_j - C_j$ matrix of the optimal simplex tableau. If two coefficients under a column have the same sign, these two goals are compatible. On the other hand, if two coefficients under a column have opposite signs, these two goals are incompatible. For example, in Table 5, under the d_1^- column, the coefficients for P_6 and P_1 are .0123 and -1 respectively. This means that priority 1--satisfying the goal of timber harvest and priority 6--satisfying the goal of snowmobiling management are incompatible. That is to say, for instance, if the forest manager wants to improve the goal achievement of snowmobiling management he must give up some timber harvest. From reading the $Z_j - C_j$ matrix of the optimal simplex tableau, it is clear that priorities 2, 3, 4 and 5 are all incompatible with priority 6. Therefore, lowering the goals of priorities 1 through 5 or any combination of them would bring about a new solution which comes closer to the goal of priority 6. But merely a qualitative description of compatibility between goals is not enough to fine-tune the goals. In order to fine-tune the goals, it is necessary to know the exact trade-offs between goals.

Trade-off Analysis

To determine the exact trade-offs among management activities, one has to look at the $Z_j - C_j$ matrix of the optimal simplex tableau. For example, under the d_1^- column, the coefficients indicate that lowering the goal of timber harvest by 1 acre would increase the achievenemt of snowmobiling management by 12.3 visitor days. Similarly, under column d_5^-, lowering the goal of camping management by 1 thousand visitor-days would improve the goal achievement of snowmobiling management by 923.8 visitor-days. Once forest managers establish the trade-offs among various management activities, they could then proceed to fine-tune the various goals. For example, if the gain of 36.9 visitor days of snowmobiling is well worth the 1 acre of timber sale preparation that would be given up then the goal of timber sale should be lowered to improve upon the achievement of snowmobiling management. On the other hand, if the 36.9 visitor days of snowmobiling is not worth the 1 acre of timber sale preparation that would be given up, the goal of timber sale will not be changed.

CONCLUSION

This paper presents a plausible solution to the problem of multiple use planning in the form of a goal programming/input-output analysis model. Throughout the paper, the pre-emptive ordinal ranking has been used to form the objective function. In a recent article Dyer et al. (1979) showed that pre-emptive ordinal ranking translate into an allocation mechanism which renders each goal a weight of positive infinity compared with a weight of zero on lesser goals. Therefore, there is no possibility for trade-off among the goals before the optimal solution is reached. Once the optimal solution is reached, however, one can determine the trade-off ratio among goals by examining the optimal simplex tableau as discussed in this paper. This infinity-zero implication of the ordinal priority ranking scheme must be stressed to prospective users of the GP-IO model presented here. Furthermore, the GP-IO model does not remove the difficulty of establishing the desired goals which must be achieved through other means.

Table 4.--Result of GP-IO analysis with varying budget level.

	Goal level	Priority	Run 1	Run 2
Budget (dollars)			277764	277864
Timber harvest (acres)	5335	1	5335	5335
Timber sale Preparation (acres)	6148	3	6148	6148
Merchantable stand Management (acres)	129070	4	129070	129070
Non-merchantable stand Management (acres)	104377	5	104377	104377
Camping management (M.V.D.)	250.7	2	250.7	250.7
Snowmobiling management (M.V.D.)	90.4	6	3.36	3.57

Table 5. The optimal simplex tableau for Run 1

Cj									P_1	P_3	P_4	P_5	P_2	P_6						
	V	C	X_1	X_2	X_3	X_4	X_5	X_6	d_1^-	d_2^-	d_3^-	d_4^-	d_5^-	d_6^-	d_7^-	d_8^-	d_9^-	d_{10}^-	d_{11}^-	d_{12}^-
	X_1	5335	1						1											
	X_2	6148		1						1										
	X_3	134641.625			1				.9845	-.0466	.9997	-.0003	-.2377							.0026
	X_4	111408.75				1			.0386	-.0408	.0519	.9998	-.9730							.0023
	X_5	250.7					1						1							
P_6	d_6^-	87.0379							.0123	.0369	.0002	.0002	.9238	1						-.0021
	d_7^-	341.6687							-.9331	.0441	-.9475	.0003	.2253		1					-.0025
	d_8^-	248.2203							-.0386	-.0408	-.0519	-.9998	.9730			1				-.0023
	d_9^-	145.5066											-1.7411				1			
	d_{10}^-	512.2642							.0283	.0850	.0006	.0005	2.1257					1		-.0048
	d_{11}^-	6.8015							-.0234	-.0800	-.0005	-.0005	-1.6679						1	-.0133
	X_6	3.3621						1	-.0123	-.0369	-.0002	-.0002	-.9238							.0021
	P_6	87.04							.0123	.0369	.0002	.0002	.9238							-.0021
	P_5	0										-1								
Zj - Cj	P_4	0									-1									
	P_3	0								-1										
	P_2	0											-1							
	P_1	0							-1											

Currently, further developments of the model are carried out along two directions: multi-period GP-IO model and multi-level GP-IO model. The first direction recognizes the fact that the GP-IO model presented here is static. A multi-period model would allow forest managers to examine, for example, the influence of their first year decision on their second year performance. The other direction - a multi-level GP-IO analysis recognizes the fact that the GP-IO model in this paper includes only one level of administration. A multi-level model such as a national-local model would enable both the national office and the local office to concentrate on different level of management details to start a feedback in establishing goals and evaluating actual achievements.

It appears that goal programming/input-output analysis fits well into the framework of multiple use management planning. It should be considered as a potentially useful tool to effectively carry out multiple use forest management.

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FORSTWIRTSCHAFT FUR VIELFATIGE NUTZUNG DURCH PROGRAMMATISCHE ZIELSETZUNG IN DER EINNAHME-AUSGABE ANALYSE

Die Zielprogrammierung (goal programming)/Input Output Analyse Model ist ein Vorschlag, um eine plausible Lösung für das problem der multipelen Benutzung der Waldbehandlung anzuschaffen. Ein hypothetisches problem ist mit dieser Technik analysiert, um aus den spärlichen Quellen eine optimale Anwendung zu erhalten. Die Verträglichkeits Analyse (compatibility analysis) und die "trade-off" Analyse sind außer der parameterprogrammierung (parametric programming) und der Spezifizierungssensitivitätanalyse (specification sensitivity analysis) auch dargestellt, um das ziel fur Waldbehandlung zu erreichen.

EXPLOITATION DE FORET POUR UN USAGE MULTIPLE PAR L'ANALYSE DES DONNEES ET RESULTATS DE PROGRAMMATION

On utilise le modèle input-output/goal programming pour arriver à résoudre le problème de gestion de la forèt multi-usage. On analyse au moyen de cette technique la répartition optimale des ressources disponibles d'un problème théorique. En plis de la programmation paramétrique et de l'analyse de la stabilité des solutions, on se sert aussi de l'analyse d'échanges compatibles et de trade-off pour obtenir les ajustements des décisions de la gestion.

MANEJO FORESTAL DE USO MULTIPLE POR LA PROGRAMACION DE OBJETIVOS (GOAL PROGRAMMING) Y EL ANALYSIS DE ENTRADA Y SALIDA

Se propone la técnica de análisis de "goal programming/input-output" para proveer una solución plausible y aparente al problema de la administración del uso de recursos forestales. Se analiza un problema hipotético con esta técnica para determinar la distribución óptima de recursos escasos. Además de programación parametrica y análisis de sensitividad específica se ejecutan análisis de compatibilidad y análisis de "trade-off" (intercambio) para permitir la refinación ("fine-tuning") de decisiones administrativas.

Agro-Forestry in the Field Experimental Forest of San Felipe Bacalar, Quintana Roo[1]

Oscar Cedeno Sanchez[2]
Javier Chavelas Polito[3]

ABSTRACT: Information is given about agro-forestry research advancements in the Experimental Forest Station "San Felipe Bacalar", Quintana Roo, Mexico. A possible solution for permanent and productive utilization of tropical soils, abandoned by the traditional agricultural practice of "shifting cultivation," is suggested. Methodological data, the agrosystems structure, polystrata and sequential organization, and preliminary results are included.

Introduction

Since the peninsula of Yucatan is a geomorphological entity, it represents a complex of problems of social, economic, and ecologic nature, somewhat different from the rest of the Mexican tropical rain forest areas. To reach an optimal development of its resources, it is necessary to account for the variety of concurrent characteristics incident there.

Among the several problems involved for an integrated performance of the tropical rain forest's natural resources, one of them is the heterogeneity of floristic composition, which complicates the application of any silvicultural methodology.

This fact has led to a selective extraction by man, of species of highest value like mahogany. This approach is leading the tropical forest to a progressive deterioration.

From the timber-man point of view, this situation gives rise to a decreasing tropical forest's value; which leads owners of forest lands in tropical zones to consider forest relicts more as a problematic obstacle than a beneficial subject. The tendency to misuse forest lands for agriculture and husbandry practices creates favorable conditions for soil erosion and wildfire propagation. This, added to monospecific crop practices, increases the danger from insect plagues, pathogenic agencies, or any other adverse factors.

Morley (1945) considers that the cause of the decline of the Mayan civilization could be imputed to an extensive soil usage, resulting in soil exhaustion. It is reasonable to think that the Mayan agricultural system of shifting cultivation with an increasing human population, imposed excessive demands on cultivated areas. This could easily have led to a forced shortening of the land resting period succeeding each crop harvest, until soils were impoverished and agriculture became rewardless.

This experience must be taken into account for those currently developing human settlements in Yucatan tropical forests. A strong migratory movement is occurring from the inhabited areas of northern Yucatan and other areas of the country to the south of the peninsula. A second way of colonization is being pursued by Government offices. It provides for concentrating people in the central zones of the country. These two colonizing waves, though having well defined peculiarities, both have a common characteristic: a strong and destructive impact on tropical forest resources.

The first is distinguished by its traditional agriculture system and by a high percent of illiteracy amongst its people. The other migratory current shows a higher cultural level, but in contrast, presents strong deficiencies for its adaption to a new, and sometimes, unknown environment. Some of these people have brought with them machines for agricultural purposes. Their applications, tried without any technical adaptation to the conditions of the peninsula, has brought negative consequences and risks of a true disaster.

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[1]Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.

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Among studious people on this subject, advantages or disadvantages of the shifting cultivation system are always a matter of polemic. The real fact is that technology has advanced, giving place to innovations like the use of machetes and chemical herbicides, which complicate the ancestral practices.

We think that multiple land-use units could be a possible solution for the problems of tropical forest areas that are being degraded and deprived of soil cover. Such forests might provide inhabitants with diversified and permanent occupation and profits to solve a number of needs, thus preventing the destructive impact of nomadic agriculture on the natural resources.

Ecological Aspects

In general, the Mexican wet-warm regions are defined by their climatic features. The annual temperature minimum mean is over 22° C, and rainfall means surpass the 775 mm.

There are no permanent water streams on the peninsula. These flow beneath a broad underground limestone plate overlying the area. During rainfall, temporary streams flow along channels or furrows. Water occasionally occurs naturally in topographic depressions commonly named "cenotes," "aguadas," lagoons, marshes, and so on.

The relief of the peninsula of Yucatan can be considered as a plateau rising from sea level to 400 meters, occasionally forming a wavy profile of hills and depressions. This relief gives place for several types of soil which the Mayan people have classified according to features like color, structure, drainage, and giving them names like tzekel, kankab, kakab, puslum yaaxhom, and akalche. The tzekel type is normally found on hilltops. The akalches are in low lying areas and are very clayish. They tend to overflow in rainy weather. Between these two extremes occur transitions of the other types mentioned above.

The vegetation is characteristic of each type of soil and can be considered as an edaphic climax.

According to the classification of Faustino Miranda (1958), most of the tropical forest of the peninsula of Yucatan could be qualified as belonging to high or medium under-evergreen forest. High jungles hold characteristic plant species like ramon (*Brosimum alicastrum*), guayacan negro (*Guaiacan sanctum*), red cedar (*Cedrela odorata*), jobo (*Spondias mombin*), mahogany (*Swietenia macrophylla*), zapote (*Manilkara zapota*), chaca (*Bursera simaruba*), guaya (*Talisia olivaeformis*), yaxnic (*Vitex gaumeri*), and machiche (*Lonchocarpus rugosus*). The low jungles have species like chechen negro (*Metopium brownei*), pucte (*Bucida beseras*), ciricote (*Cordia dodecandra*), tinto (*Haematoxylum campechianum*), and caracolillo (*Mastichodendron* spp.).

The species of the high and medium under-evergreen tropical forests are localized over the soils like tzekel, kakab, kankab, and yaaxhom. Many of them suffer leaf casting during the dry season (February-April). The species of the low cadufolius tropical forest live on akalche soils. On transitional soil sites, species of high and medium-types are mixed with others of the low forest type, thus forming ecotones.

Mangrove vegetation is established along the litoral zones. This is formed by species of botoncillo mangrove (*Conocarpus erecta*), red mangrove (*Rhizophora mangle*), etc. living on flooded soils or marshes. These species are featured by their habits of forming aerial roots.

The so-called "savannahs" must also be considered. These biogeographic conditions are formed by plain and floodable grounds with saline soils, supporting species like guiro (*Crescentia cujete*), nance (*Byrsonima crassifolia*) and diverse other species of halophytic grasses.

Problems of the Region

To elucidate the incident factors now acting in the peninsula, mainly those concerning social aspects, it is necessary to review the historical background of the inhabitants of the region.

In the historic past, the fight for subsistence on the peninsula of Yucatan was not so hard as today, because of a low density of population, an abundance of land, the establishment of cattle haciendas, and the golden era of the henequen, a textile fiber of great world demand. This provided culture and a certain degree of social peace.

At present time, the Mexican henequen has been displaced by synthetic fibers and by imported henequen fibers produced at lower costs in other countries. This fact has caused unemployment, migration, and an increased use of soil for agriculture crops subsistence. Furthermore, the native population in the peninsula has increased greatly from within and by the addition of grants, from other areas, settling mainly in the States of Campeche and Quintana Roo. This is strongly pressing the natural resources of the area.

The tropical rain forest in the peninsula, as mentioned, is characterized by a profuse but heterogeneous mix of tree species, only a few of which are used by technology, a fact which has brought profits from the resource but caused a progressive deterioration of the genetic resources of these forests.

These circumstances make the forest land-owners utilize the resource only for its nourishment, using the soil for agriculture purposes practicing the system of clearing-tumbling-firing (shifting cultivation system) and seeding for survival through a very few years of corn, rice, and other crops. The

agricultural practice of clearing-tumbling-firing is the main feature of nomadic agriculture that has influenced the disappearance of tropical forests. Because of the increase in population, the broken land is overused for food production. Soil fertility in the peninsula permits cropping for only 2 or 3 years, followed by a resting period of 4 to 8 years. Native people must continually open land for agriculture from areas of jungle cover.

The agriculture in this zone is considered as having a very low efficiency for exploitation of the ecosystem, since it requires hard human labor to obtain the maximum yield of energy.

Agro-silvicultural Research

Confronting the problems of the peninsula of Yucatan, we must recognize the need to search for solutions which permit harmonizing factors of human needs to the question of man's subsistence.

We are reminded that tropical forests are constituted by a great diversity of species with different nutritional requirements and habits, and persisting through thousands of years taking an optimal advantage of soil and allowing a harmonious existence of all its components. Injurious or beneficial elements have evolved and each is important to keeping a biological equilibrium.

The agro-silvicultural unit attempts to replicate nature while combining several agricultural, silvicultural, and husbandry activities, which are managed to maintain optimal soil yields without risk of injury to fertility, while securing productivity for future mankind's benefits.

Objectives

In the search of solutions for the problems exposed, the agro-silvicultural unit is addressing the following objectives:

- Supplying forest inhabitants with a system that could allow a raising of their standard of living.
- Diminishing human impact on the ecosystem by reduction (control) of the nomadic agriculture now in practice.
- Eliminating mono-crop practices by favoring crop diversification and rotation in order to attain the proper use of soil.

These objectives are reinforced by a critical and comparative examination of features of both monoculture and policulture systems, as shown in table 1.

The Agro-silvicultural Unit

To facilitate research on agro-silviculture, an experimental modulus was established in Bacalar, Quintana Roo. It is a rectangular area of 12 ha (200 m x 600 m) circumscribing concentric rectangles (see fig. 1), and designed to support a single family of 6 members.

Table 1.--Comparative features of monocultural and agro-silvicultural systems

Features	Monoculture	Agro-silviculture (polyculture)
1. Structure	Unidimensional	Multidimensional
2. Architecture	Antecological	Ecosystem
3. Plant sanitations	Plagues of high and sudden propagation	Few plagues, naturally controlled
4. Peasants occupation	Only seasonal	Permanent
5. Production	Casual	Sustainable
6. Man's capability profits	Limiting	Not limitative
7. Sociocultural	Imports techniques	Traditional experience diminishes nomadic practices
8. Ecological impact	Destroys environment and accelerates its decline	Protects the ecosystem

The modulus contains:

A. A peripheral strip of 5 m width and 7,900 m^2 of total surface, for planting species like *Gmelina arborea* for celulose, amapola (*Pseudobombax ellipticum*) for plywood, and tatuan (*Colubrina arborescens*) for rural construction materials (fig. 1, sec. 1).

	No. of individuals	Planting date
Gmelina arborea	44	(1975)
Gmelina arborea	640	(1977)
Amapola	130	(1975)
Tatuan	353	(1975)

Establishment success: 100%

B. A second inner peripheral strip, of 20 m width and 29,600 m^2 surface, where 11 species of forest trees have been planted. Establishment of 100% has been reached (fig. 1, sec. 2) (fig. 2 and 3).

C. A third area (20 m wide and 29,400 m^2) with 550 trees belonging to 11 planted fruit species. Establishment achieved is 100% (Guanabana, Mandarin, Naranja, Zapote, Maranon, Aquacate, Banana) (fig. 1, sec. 3).

In this area the Guanabana trees showed poor growth, particularly in low sites with poor soil; and Maranon could not definitively adapt. Some citrus species (mandarin orange and common orange) began fruiting, as did zapote species. Avocados are initiating fruit production. A fruit crop will begin in 1981.

At the central part of the major rectangle is an area of 510 x 100 m divided by a central strip, in which 406 coconut trees were planted. Establishment success is 100% (fig. 1, sec. 5).

At both sides of this strip there are 6 rectangular plots, 175 x 50 m (8,750 m^2 each) giving a total area of 52,500 m^2. In four of these plots the following forage plants have been planted (fig. 1, sec. 4A, 4B, 4D, 4E)(fig. 4):

Giant grass	*Pennisetum purpurem*
Rhodes grass	*Chloris gayana*
African star	*Cynodon plectostachyus*
Yucatan's chaya	*Cnidoscolus chayamansa*
Tabasco's chaya	*C. chayamansa*
Ramon	*Brosimum alicastrum*
Guaje	*Leucaena esculenta*
Huaxin o guaje blanco	*Leucana leucocephala*

Forage herbs and shrubs have been maintained under observation in order to define adaptation in the Unit. Species like *Leucaena leucocephala* show promise of success for forage and food production. In contrast, *Chloris gayana*, the Rhode grass, could not adapt because of the kind of soil in the area and its watering needs.

Another plot has been dedicated for annual and biannual crops like achiote (*Bixa orellana*). The 1978 yield was 100 kg from the seeds of 274 achiote plants in the Modulus; that of 1979 was 210 kg; and 1980's, the last one, reached 120 kg (fig. 1, sec. 4C, 4F)(fig. 5).

Figure 1.--Distribution diagram of modulus multipurpose soil sections.

Figure 2.--Species planted in the forestry section of the modulus.

Figure 3.--Plantation of *Simarouba glauca* (negrito) in the forestry section, in combination with *Cynodon plectostachyus* (African star grass).

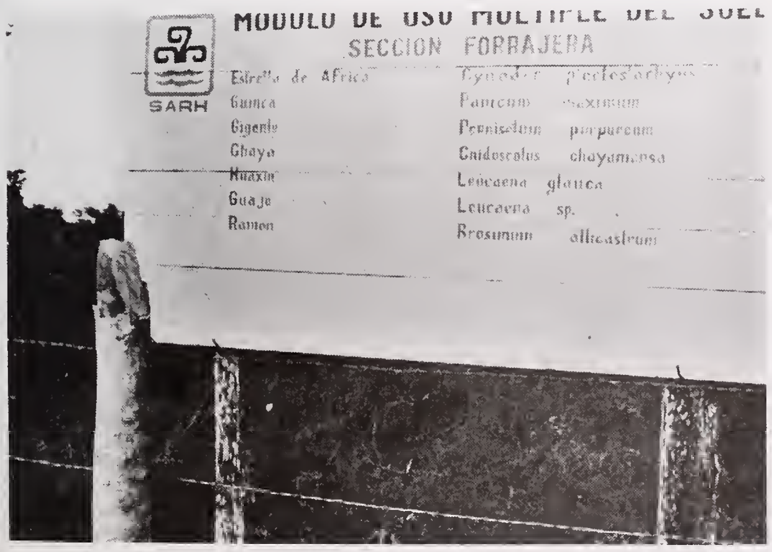

Figure 4.--Species on the forage section.

Figure 5.--Species in the agricultural crops section.

Alternate seeding of yucca o cassava (*Manihot esculenta*) with achiote, has resulted in some specimens of average weight of 18 to 25 kg in a single year. In accordance with the soil conditions, during 1979 we established in this area 1,200 banana trees of five varieties from areas with good fruit crops from the 1976 and 1977 plantage.

For the forest tree species, annual data are taken on survival, height-diameter (D.B.H.), insect and disease attacks, and information related to flowering and fruiting patterns. Some pruning practices are applied for bole conformation.

On species like maize (*Zea mays*), bean (*Phaseolus vulgaris*), yucca (*Manihot esculenta*), achiote (*Bixa orellana*), and barbasco (*Dioscorea composita*) the data obtained are similar to those used in typical agriculture.

Cleaning off weeds in plantations is carried out every six months. The same schedule is used in the forest, as in fruit tree and agricultural cultivating areas.

Results from the Modulus Experiment

Responses of forest tree species has been related with soil type. For example, species of masculis (*Tabebuia rosea*), mahogany (*S. macrophylla*), red cedar (*C. odorata*), and pich (*Enterolobium cyclocarpum*) show good height growth and diameter increases, when growing on more or less deep soils. Such responses are not shown with some species like ramon (*Brosimum alicastrum*) or cobano. *Gmelina arborea* has difficulty growing in rocky soils, but has a very good increase in height and diameter in deep soil. Several species, for example *Tectona grandis*, didn't adapt well to any soil type. Perhaps this is an effect of inadequate selection

of seed provenance, and few of the remaining individuals have reached good height. In contrast, some species like negrito (*Simaruba glauca*) have adapted to any kind of soil. Observations of plague-host correlations are another of the tasks carried out in the modulus, in order to determine some possible problems of incidence and severity of plagues on the prevailing plant species.

As mentioned earlier, one of the more conspicuous features of the peninsula of Yucatan is its heterogeneous soil distribution. This is also the situation in the modulus and probably causes some fluctuation in the observed results.

In general terms it may be said that plantations have a good development on "kankab" and "yaaxhom" soil types, better than on those soils known as lower or "akalches." On the "akalches," some grasses (African star), finest species (*Cordia dodecandra*) and rice, show better growth. Through 1979, the cattle grazing production coefficient, based on grass and shrub production on the modulus, is a cattle load of 1.5 havines and 2.5 ovines per hectare.

On the basis of experiences gained from the modulus experiment, it is possible to recommend establishment of new units for combined production, at other tropical zones in Mexico, like those at Uxpanapa and Papantla in the State of Veracruz.

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AGRO SILVICULTURA EN EL BOSQUE EXPERIMENTAL DE SAN FELIPE BACALAR, QUINTANA ROO

Este informe contiene información acerca del progreso de las investigaciones de agro-dasonomía en la Estación Experimental Forestal "San Felipe Bacalar," Quintana Roo, México. Se sugiere una posible solución para la utilización permanente y productiva de suelos tropicales, que han sido abandonados por la práctica tradicional agrícola del sistema de rotaciones de cosecha. Se incluyen los datos metodológicos sobre la estructura de los sistemas agronómicos, poliestrata y organización secuencial, y resultados preliminares.

L'AGRO-SYLVICULTURE À LA STATION DE RECHERCHE DE SAN FELIPE BACALAR, QUINTANA ROO

Cette étude donne des renseignements sur les progrès des recherches agroforestières à la station de recherche forestière "San Felipe Bacalar," à Quintana Roo, au Mexique. Elle suggère une solution possible pour l'utilisation permanente et productive des sols tropicaux abandonnés par la pratique agricole traditionnelle de l'assolement. Elle comprend aussi des données méthodologiques, la structure des agrosystèmes, l'organisation à couches multiples et séquentielle et les résultats préliminaires.

AGRAR-FORSTWIRTSCHAFT IN DEN EXPERIMENTALLEN FORSTEN VON SAN FELIPE BACALAR, QUINTANA ROO

Einige Information über Fortschritte der Agrar-Forstwirtschaftsforschung der forstlichen Versuchsanstalt San Felipe Bacalar, Quintana Roo, Mexiko, ist zusammengetragen. Eine mögliche Lösung ist vorgeschlagen, die tropischen Böden permanent und produktiv zu benutzen, die von traditionellen landwirtschaftlichen Methoden der Übernutzung und Verwüstung nachblieben. Daten an Methodologie Agrarsystemstruktur, Mehrfachschichtung und aufbauender Organisation, sowie vorläufige Ergebnisse sind eingeschlossen.

Multiple-Use Research in Israel[1]

R. Karschon[2]

Abstract.- The status of multiple use research in Israel is reviewed. Available data on water, range and recreation could serve as a basis for multiple use management of forests.

Israel is by no means an undeveloped country, yet in spite of conspicuous achievements in reforestation and afforestation of difficult sites, forestry practice is still in its early stages of formation. This is due to the geographical setting of Israel at the edge of the Saharo-Arabian desert, the poor condition of its natural forests as a result of widespread abuse and destruction until the very recent past, the relatively young age of its man-made forests, and the lack of both a forest tradition adapted to local conditions and a policy stressing the value of the forest and its potential benefits within the socio-economic framework of a young and dynamic State.

It is, therefore, hardly astonishing that the application of the multiple use concept is regretfully still in its beginnings. Forest managers pay lip service to its lofty principles while avoiding antagonizing various vested interests and the noisy minority of 'ecology', nature conservation and outdoor recreation fans who claim the countryside as their exclusive domain and dismiss as irrelevant and non-existent the economic role of forest plantations to provide home-grown timber. Since its inception, forest research was busy with laying the foundations of sound forestry practices by emphasizing mainly biological and technical aspects rather than forest management and influences, although in retrospective much of the work on forest influences would today be termed multiple use research. Much like Moliere's Bourgeois gentilhomme, who did not know that he was talking prose, forest scientists now come to acknowledge that, surprisingly, multiple use research in Israel dates back to the late 1950s.

Hopefully, the aim of multiple use research should be to investigate all, or at least several, potential management objectives on the same site(s). No comprehensive approach of this kind was, however, attempted in Israel. This is due in part to the fact that forest research could not remain indifferent to public discussions on the very role of forestry in this country, and to a certain degree multiple use research responded to the challenges of the decade. In the fifties, reforestation was accused of competing for land with animal husbandry (grazing); in the sixties, forests were reviled as spendthrifts of much needed water for agriculture and industry, while the seventies saw the upsurge in misunderstood 'ecology', care for the environment, nature protection and recreation, which are claimed to be incompatible with reforestation and wood production. (The challenge of the eighties has yet to materialize...) One outcome of these challenges was a series of partly unconnected research papers which, if properly read and taken into account, could provide some foundations for the multiple use management of our main forest types - oak scrub (maquis), pine and eucalypt plantations. The purpose of this note is not to review all relevant publications but to focus attention on some of the major research projects and their implications.

Seligman and Douer (1970, 1971) investigated the grazing value of the herbaceous vegetation in pine plantations. They found that competition between the tree story and ground cover results in a marked depression of the latter, but there always exists a certain amount of herbs that can be grazed. They concluded that pine plantations constitute a valuable seasonal source of forage; to increase their grazing value, an intensity of thinning would be required that could provide an optimum crown cover canopy for forage production compatible with other management objectives. Data by Seligman and co-workers (1959) on the grazing potential of maquis and garigue, the wood production of which (though locally important) is insignificant, could be of value for the multiple use management of areas gazetted as forest reserves and administered by the Forest Department. Large-scale plantings of carob ('St. John's bread') for fodder in the fifties and early sixties were discontinued following unfavourable reports on their nutritional value (Bornstein et al. 1963, Volcani and Rodrig, 1961).

Research on the water balance and evapotranspiration of forests was conducted by several

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[2] Director, Forestry Division, Agricultural Research Organization, Ilanot, D.N. Lev haSharon, Israel. Paper presented by Gerald Gottfried, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Tempe, Arizona.

authors. In an extensive investigation on Mt. Carmel, Shachori and co-workers (Rosenzweig et al., 1972) found that evapotranspiration is highest in oak scrub and lowest in natural pasture and bare land, with pine occupying an intermediate position. In contrast, Cohen et al. (1966), working in the Judean Hills, found that the water balance of pine plantations and natural herbage is essentially similar. Karschon (1971) and Karschon and Heth (1967) determined that the evapotranspiration of eucalypt is higher than that of a bare field. All these data could be valuable for manipulating the vegetation cover if increased water yields are aimed at, provided that due account is taken of the other - direct and indirect - benefits of the forest and that the extra water can be recovered economically. In this context it is noteworthy that eucalypt planted on peat exposed after drainage reduces levels of soil nitrates contributing to the eutrophication of Lake Tiberias (Zohar 1976).

For investigations on the recreation potential of forests a novel, objective approach was used. Hourly and daily microclimatic data obtained by conventional measuring methods were used to compute the heat stress, i.e., the required sweat rate, and the thermal sensation of man. This approach is most suitable under Mediterranean conditions with a hot summer and cool winter but would require some re-examination under different climates. (In England, sunny areas are likely to be preferred for outdoor recreation in the summer, to the dense shade of planted forests.) Not unexpectedly, it was found that optimum conditions in the summer are provided by closed pine plantations with a canopy cover of ca. 80%, heat stress and thermal sensation being inversely related to canopy closure. There is, therefore, no conflict of interest between management for timber production by silvicultural thinnings and management for recreation. In contrast, suitable conditions for recreation in the winter prevail outside the forest in open oak scrub, the closed pine forest being too cold for thermal comfort. This points to the fact that areas destined for recreation should comprise, side by side, dense stands and open vegetation. Similarly, eucalypt plantations in the desert are convenient for recreation in the summer, while in the winter the open desert will be preferred (Karschon and Schiller, 1976).

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INVESTIGACION DE USO MULTIPLE EN ISRAEL

Se describe el estado actual de investigaciones sobre uso múltiple en Israel. Datos disponibles sobre agua, pastizales y recreo podrían servir como base para el manejo forestal mediante uso múltiple.

VIELFALTIGE NUTZUNGSFORSCHUNG IN ISRAEL

Der Stand der Forschung über vielseitige Nutzung in Israel ist besprochen. Vorhandene Daten über Wasser, Weideland und Erholungsstätten können als Grundlage für die Bewirtschaftung vielseitiger Nutzforsten dienen.

RECHERCHES SUR LES "USAGES MULTIPLES" EN ISRAEL

La pratique de la sylviculture en Israël en est encore à un niveau élémentaire de son développement. La recherche forestière essaie de répondre aux questions posées par des groupes divers, souvent ayant des intérêts contradictoires, sur l'importance de la sylviculture en Israël. Bien qu'on n'ait pas fait de projets spécifiques de recherche sur les usages multiples, on peut bien interpréter beaucoup de la recherche déjà faite sur les influences forestières comme une recherche sur les usages multiples. Il existe aussi des données sur l'eau, sur le pâturage et sur la récréation qui pourraient servir de base pour l'exploitation à usages multiples des forêts d'israël.

Session III

Application of Multiple-Use Research

Bostjan Anko, Moderator

Edvard Kardelj University, Yugoslavia

The five papers presented in this session dealt with a wide range of related problems reflecting the natural as well as socio-economic specifics of the countries represented. As such, the session offered a very good review of the status of multiple-use research in various countries.

In the first paper, A. Doyen addressed the theoretical as well as practical problems of multiple-use agro-forestry in Senegal, stressing the importance of considering biotic, abiotic, and socio-economic givens of a region considered. In the discussion that followed, the importance of involving local people at all stages of a project was stressed.

The case study of multiple-use research from Honduras (V. Castellanos, J. Thames) pointed out the need and importance of obtaining data to ensure the support of the projects. The results obtained by computations based on hydrological and meteorological observations are in strong agreement with empirical results.

A different set of priorities in highly developed countries was illustrated by the presentation on the status of multiple-use research in Belgium (P. Gathy). There multiple-use of the forest may not be so important as a means of improving the economic situation of the population, but rather as a means of improving the general quality of life. As such, multiple-use forestry could be considered as an important argument in preserving forests from competing land uses.

Several successful applications of multiple-use research in Pakistan were presented by M. I. Sheikh. They included a wide variety of practices whose main purpose is to increase the income of local inhabitants or to protect the stability of ecosystems. The paper also stressed the importance of the general public seeing the results of such projects as a means of securing its cooperation.

Two closely related forest functions (water and soil protection) were dealt with in the paper by V. Perina of Czechoslovakia, presented by P. Ffolliott. The paper emphasized the importance of the fact that these functions (like many others) are not only affected by our deliberate actions, but also by the side effects of general forest management practices--in particular by the harvesting methods.

Integration of Multiple-Use Forestry Research in an Environmental Study of a Rice Development Project in the Guinean Zone — Lower Casamance — Senegal[1]

André Doyen[2]

Sylviculture must conciliate ecological and socio-economic factors. The forest is an open ecosystem in relation with natural factors: abiotic, biotic and anthropic. In this context, priority should be given to the relation between research and development and research should satisfy the needs of the user. Dialogue with the producer is one element of this new spirit of the researcher. To this end, an environmental approach by multi-disciplinary teamwork seems necessary. It not only expresses the need to adhere to reality, but also to promote an inner eco-development. Thus a complete knowledge of the environment and use of simple techniques are keys to success. This paper highlights the lack of communication among the various specialists involved in the recently developed notion of multiple use forest which constitutes one of the essential elements of rural space. It underlines the new orientation of sylviculture,i.e. an integrated management of the multiple use forest. An application of this method in the forest of TOBOR in Lower Casamance SENEGAL is provided.

MULTIPLE USE FOREST

The forest is a vegetal cover which satisfies a great many human needs. As such, it occupies a privileged position in the rational management of natural resources, protection of the natural environment, and ecodevelopment.

Roisin (1975) has noted that "The notion of multiple-use forests requires from now on that the conscientious forester endeavors to make his "art" useful to contemporaries and future generations. These multiple uses are protection and production, climatic, hydrological, recreational and touristic, scientific and educational, sanitary, esthetic and hunting. (Hunting integrates the production, recreational, touristic, scientific and educational functions.)

Only integrated management can resolve problems associated with the multiple use forest.

The forester should be receptive to the different natural and social sciences as they relate to his work; he should work multidisciplinary teams.

The integrated approach of the forest ecosystem is fundamental and permits an analysis of the impacts of human intervention.

[1] Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.

[2] Charge' de cours, Institute of Environmental Sciences, Faculty of Sciences, University of Dakar, Senegal.

According to Clicheroux (1971), the management of multiple use forests cannot be considered marginal in the nation's development. The forest is an essential element in rural space.

The forester should therefore play an important role in the organization of environmental and resource development planning.

AN ENVIRONMENTAL APPROACH

This team-oriented multidisciplinary approach is based on an analysis of three fundamental environmental factors: abiotic, biotic, and anthropic.

It focuses on qualitative and quantitative data concerning potential yields, actual yields, and society's demands. The "art" of the forester is to arrive at an equilibrium that balances these three parameters. For this purpose, the following diagnostic is established:

Parameters	Diagnostic
Potential yield > Actual yield	Under exploitation
Potential yield = Actual yield	Balanced exploitation
Potential yield < Actual yield	Over exploitation
Actual yield > Society's demand	Surplus production
Actual yield = Society's demand	Balanced production
Actual yield < Society's demand	Under production

It should be noted that numerous eco-development projects do not adhere to the principles of integrated multiple use forestry. In other cases, economic and political considerations orient feasability studies towards a minimum level of project intervention. Thus, the "do-nothing" alternatives are rarely considered or proposed.

In order to be realistic, we believe that the improvement and management of production systems without heavy capital investments, utilizing simple and appropriate technologies, and minimizing changes in cultural traditions, represents a more efficient solution.

Finally, we believe that communications, training, extension, and demonstration programs, as well as efforts to motivate the rural population and encourage them to accept responsibility for future, are absolutely necessary for the successful execution of development projects.

Application: Tobor Forest (Lower Casamance, Senegal).

Methodology.

The author has carried out a study of the Tobor Forest in the following way:

Bibliographic and cartographic survey (Aerial photography).

Field surveys.

Discussions with the concerned population, and religious and political leaders.

Observation of vegetal cover at medium and micro scales.

Identification of real problems and limiting factors (ecologic and socio-economic).

Identification of central themes and criteria.

As noted above, this approach is based on "operational", or "applied" ecology, as well as the socio-economic variables in the zone (in other words, an "environmental approach").

The intention was to achieve endogenous ecodevelopment in harmony with the natural environment. To this end, the following themes were emphasized:

Integration of multiple use forest principles integrating sylviculture and other land use.

Improvement of rational management towards conservation for future generations.

Involvement of the population in improvements.

Increase population capacity for food self-sufficiency.

Continue efforts against desertification.

Objectives of Project

Qualitative and quantitative improvement of forest production.

Integration of forest development into general ecodevelopment of the project zone by:

. realization of mixed sylvo-agricultural systems,

. training of personnel,

. motiviation of the population.

Increase the area under rainy rice cultivation.

Increase other productive activities (nuts, bee-keeping, etc..).

Preserve the natural milieu.

In sum, to improve the productivity and value of the multiple use forest.

Description of Tobor Forest

Location: In the Region of Lower Casamance, between Ziguinchor and Bignona.

Area: Managed by F.A.O - 4300 Ha.
Under rice cultivation - 15 Ha in 1979/80.

Project Title: Forestry Project of Ziguinchor (F.A.O - U.N.D.P).

Classification: Forest reserve.

Geology: Sandy formations of the quaternary "Continental Terminal".

Hydrogeology: Water is found in red sands of the plateau and the sandy terraces at less than 10 meters depth.

Geomorphology: Plateau.

Pedology: Red ferralitic soil (leached).

Climate: Characterized by a 7 month dry season and a 5-month rainy season (June-October), it is of the Guinean - Lower Casamance type, of the Sudano-Sahel variety.

. annual average temperature: 25.2^{o} to 26.3^{o} C,

. monthly average temperature:

-minima: 23.2^{o} to 24.6^{o} C in January,

-maxima: 26.5^{o} to 27.8^{o} C in May/June,

. low range of temperature: 3.2^{o} to 4.1^{o} C,

. average annual rainfall: 1200 to 1750 mm,

. rainfall 1979: '850 mm, (dry year).

Phytogeographic zone: Northern limit of the Guinean area, related to sudano-guinean.

Vegetal cover: Light to dense forest, semi-arid, in two strata, full-grown and small trees. Mixture of Sudano and guinean species, small trees, vines, and herbaceous plants.

History

Originally three main species were in the dominating strata: Parinari excelsa, Erythrophlaeum guinense, and Detarium senegalense.

There were numerous other dispersed Guinean species: Albizia ferruginea, Albizia zygia, Alstonia boonei, Antiaris africana, Chlorophora regia, Cola cordifolia, Daniellia thurifera, Dialium guineense, Markhamia tomentosa, Morus mesozydia, Ricinodendron heudelotii, Sterculia tragacantha, Treculia africana. The coppice also differed from that of Sudanese - Guinean area: Anthostema senegalensis, Carapa procera, Ekebergia senegalensis, Fagara lerieurii, Malacantha alnifolia, Monrida geminata, Pachystela brevipes, Parinari macrophylla, Samanea dinklagei, and among the shrubs: Cassis podocarpa, Uvaria chamae, Voacanga africana.

According to Aubreville (1948), this previously stretched over the whole territory of the Low and Medium Casamance, except for the mangrove and the marshy depressions. It was linked in the east with the Fouta-Djalon massif, and descended to Lower Guinea.

The farmers alone are not responsible for the degradation of the primitive forest. Changes in the primitive forest state were also registered in places which had never been cultivated. Mobile fires were and more than ever are the main biological factor causing the degradation.

The Guinean forest, in spite of its density, is easily set on fire at the end of the dry period because (1) the soil is covered with leaves, and (2) the bushy and sarmentous understory which competes with the high forest for water, is in a vegetative rest state. Having been set on fire year after year, it becomes harder and harder for the coppice to regenerate. As a result it has thinned out and is progressively replaced by ligneous plants and gasses that are more fire-susceptible. Previously almost entirely safe, the high trees are then also set on fire. Some of them die, dry, and feed more serious fires, seriously damaging the overstory. This process, which has gone on for centuries and which has been intensifying for decades explains why there are only very few almost safe forests left, exclusively located in the most humid areas. The recent ban on fires controlled by the forest department, which limited damage during fires between March and June, will certainly result in the disappearance of the last Guinean species because experience shows that the village voluteers themselves are not able to stop or even to bring the fire under control.

All areas lost by the Guinean forest have been rapidly invaded by a much stronger savanna similar to the Guinean one. The results in the coexistence of two floras in the northern part of the Casamance and the increase of Sudanese species in almost all types of environment. Afrormosia laxiflora, Daniellia oliveri, Khaya senegalensis, Parkia biglobosa, Prosopis africana, Pterocarpus erinaceus have invaded the overstory; Annona senegalensis, Bridelia micrantha, Cassia sieberiana, Ximenia americana have invaded the inferior strata. Acacia albida and Guiera senegalensis appear on almost all grounds cleared by the farmers. The original forest landscape is then suddenly transformed into another without any noticeable climatic change or any change in the soil characteristics.

Project Description

The FAO-UN Development Program project cosists of:

. Cutting down, hauling, and burning out dead stumpage. These operations are called sanitation cutting.

. Judiciously exploting the wooded, particularly shrubby stratum in order to create at the soil level a micro-environment favorable to germination of seeds that come from reserved seed-bearers. This is done without destroying the natural environment which is the basic condition of a natural regeneration of native commercial species.

. If there are not seed-bearers enough for regeneration, the forest department directly steps in to help regeneration by working the ground and growing man-made augmenting plantations in rows.

. In difficult cases where a forest is completely deprived of main species, the only remaining possibility is an artificial intensive plantation.

. Protecting the forest by establishing a network of fire-breaks for producing rice together with darcassou (Western Anarcardium) by row seeding (4 meters between the rows). In addition there are peripheral firebreaks which limit the forest surface. They are 50 meters wide. There are also road fire-breaks designed to avoid fires caused by discarded cigarettes (50 meters wide). Finally, there are supplementary fire-breaks inside and on

the edge of the forest that divide the forest into compartments, making it possible to fight fires rapidly.

. Sanitation cutting (old wood) is designed to remove all flammable material and recover wood for carbonization. By producing quality charcoal with high yield (dry stumpage) up to 33%, they hope to supply the steadily growing market of the Dakar region, and consequently reduce pressure of demand on the northern sahelian forests and those lying near the capital.

. This pilot project attempts to show that this type of planning is feasible, and could be financed by investing the profits made by selling wood, processing, sawing, milling of ligneous products, harvesting the darcassou (cashew) fruit, and developing an area after thinning, as well as rice production.

All these operations should be carried out by recycling the profits (self-financing). The areas to be improved will be rather large. This year it has been planned to process 100 ha, including 60 ha to be completely replanted.

Involving the local population by:

- allowing them to clear the land from shrubs and grow rice within the rice fire-break area and the reforestation lots together with plantations, thus avoiding expensive upkeep and indirectly protecting them from fire. This year 15 ha of rainy rice were cultivated for the first time. Production has been good despite light seed density.

- training a skilled staff for carbonization, wood farming, and plantations (nursery...).

- integrating forests upstream, and industry downstream.

Plantations and enrichment of exotic species are carried out with teak (Tectona grandis) and Gmelina (Cafal tree).

Promising results have been obtained with Eucalyptus camaldulensis and Terminalia superba. Nevertheless, priority is given to local species development:

- Carbonizable wood: Afzelia africana (Lyncke), Chloroplora regia (Tombero noir), Danielle ogea (Santan For), Khaya sénégalensis (Cailcédrat), Danielle oliveri (Santan), Ptérocarpus erinaceus (Vene), Albizzia adiantifolia (Baneto), Cordyla pinnata (Dimb), Schrebera arborea (Bouyoupa), Erythrophleum guineense (Tali), Erythrophleum africanum Pelli), Parinari excelsa (Mampato), Detarium senegalense (Ditah), Prosopis africana (Ir.).

- Non carbonizable wood: Antiaris africana (Tombero blanc), Ceiba pentandra (Fromager), Donibax costatus (Kapokier), Mitragyna stipulosa (Bahia), Alstonia boonei (Emien), Ricinodendron heudelottii (Ricinodendron).

4. CONCLUSIONS.

The Tobor Forest in the Lower Casamance provides an example of the effectiveness of the integration of a multiple-use forest in eco-development.

The following lessons can be drawn:

. The sociologist plays a key role in raising the consciousness level and motiviation of the population to improve the agricultural practices.

. Training of local labor has extremely important effects on the social development of the area.

. There are opportunities to study the relationships between ecological characteristics and socio-economic principles.

. There are opportunities to improve primary and secondary forest production.

. Sylviculture can be integrated in sylvo-agricultural systems.

. Rational management of forest resources which guarantees the yearly production are being carried out to protect the natural resources of Senegal.

Finally, we believe that the conclusions from Tobor Forest Project can be generalized with several adjustments to the light and semi-arid forests throughout the Lower Casamance in Senegal.

The diagram summarizes the central themes of the approach discussed in this paper.

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INTEGRATION DES RECHERCHES FORESTIERES SUR L'USAGE MULTIPLE DANS UNE ETUDE DE L'ENVIRONNEMENT D'UN PROJET DE DEVELOPPEMENT DE RIZ DANS LA ZONE GUINEENNE, BASSE CASAMANCE, SENEGAL

La sylviculture doit concilier les impératifs écologiques et socio-économiques. La forêt est un écosystème ouvert en relation avec les facteurs du milieu: abiotiques, biotiques, et anthropiques. Priorité sera donnée à la relation recherche-développement. La recherche s'orientera et s'adaptera aux contraintes de l'utilisateur. Le dialogue avec le producteur est un élément de ce "nouvel esprit" du chercheur. Une approche environnementale nous semble fondamentale par le travail en équipe pluridisciplinaire. Elle traduit le souci de collé à la réalité et de promouvoir un écodéveloppement endogène. Ainsi, la connaissance parfaite du milieu, l'utulisation de techniques simples et la motivation profonde des populations sont les facteurs clés de succès. Notre document met en exergue le manque d'information entre les divers spécialistes face au développement récent de la notion de forêt à usages multiples qui en fait un des éléments déterminant de l'espace rural. Il souligne l'orientation future de la sylviculture: une gestion intégrée de la forêt à usages multiples. Un exemple: forêt de TOBOR, en Basse Casamance, au SENEGAL.

LA INTEGRACION DE INVESTIGACIONES FORESTALES DE USO MULTIPLE EN US ESTUDIO AMBIENTAL DE UN PROYECTO DE DESARROLLO DE ARROZ EN LA SONA DE GUINEA, BAJA CASAMANCE, SENEGAL

La silvicultura debe conciliar los imperativos ecológicos y socioeconómicos. La selva es un sistema ecológico abierto en relación con los factores del medio ambiente: abióticos, bióticos, y antrópicos. La prioridad será dada a la relación investigación-desarrollo. La investigación se orientará y se adaptará a las obligaciones del utilizador. El diálogo con el productor es un elemento de esta "nueva mentalidad" del investigador. Una aproximación al medio ambiente para el trabajo en equipos con diferentes disciplinas nos parece fundamental. Esto traduce la preocupación de acercarse más a la realidad y de promover un desarrollo ecológico endógeno. De esta manera, el conocimiento perfecto del medio ambiente, la utilización de técnicas sencillas y la motivación profunda de las populaciones son los factores clave del éxito. Nuestro documento pone de relieve la falta de informaciones entre los varios especialistas frente el desarrollo reciente de la noción de selva con usos múltiples y que hace de esto uno de los elementos que determina el espacio rural. Hace hincapié en la orientación futura de la silvicultura: es una gestión integrada de la selva con empleos múltiples. Un ejemplo concreto es dado, es el de selva de TOBOR, en Baja Casamance, en SENEGAL.

INTEGRIERUNG VON VIELFALTIGER NUTZUNGSFORSCHUNG EINER UNWELTSSTUDIE EINES ENTWICKLUNGSPROJEKTES FUR REISERZEUGUNG IN DER GUINEANISCHEN ZONE, LOWER CASAMANCE, SENEGAL

Die Forstwissenschaft muss die ökologischen und die sozio-wirtschaftlichen Imperativen versöhnen. Der Wald ist ein offenes "Ecosystem" in Verbindung mit den "biotischen, abiotischen und menschlichen" Faktoren der Umwelt. Die Priorität wird der Relation "Forschung-Entwicklung" gegeben. Die Forschung wird sich nach den Schwierigkeiten des Benutzers orientieren und sich ihnen anpassen. Der Dialog mit dem Erzeuger ist ein Element von diesem "Neuen Geist" des Suchers. Eine Annäherung mit dem Umwelt scheint uns fundamental zu sein, indem die Arbeit durch eine mehrfach disziplinarische Gruppe ausgeführt wird. Sie versucht sich der Realität anzupassen und eine innere ökologische Wicklung zu befördern. Die perfekte Kenntnis der Umwelt, die Benutzung von einfachen Techniken und die gründliche Motivation der Bevölkerungen sind die Hauptfaktoren des Erfolgs. Unser Dokument hebt den Mangel von Auskunft hervor zwischen den verschiedenen Spezialisten gegenüber der Kürzlichen Entwicklung des Waldbegriffes von mehrfacher Benutzung, die eins der bestimmten Elementen des Landraumes ist. Es betont die zukünftige Orientierung der Forstwissenschaft: Eine integrierte Waldverwaltung von mehrfacher Benutzung. Ein Beispiel Wald von TOBOR in der Basse Casamance, SENEGAL.

Application of Multiple-Use Research on Watersheds in Honduras[1]

Vladimiro Castellanos[2] and John L. Thames[3]

The effects of typical land use practices on soil erosion in the upland watersheds of Honduras were studied on a 270 km^2 watershed located near the capital city of Tegucigalpa. The data collected were analysed with the Universal Soil Loss Equation and with a Hydrologic Model (HYMO) to determine the probable rate of sedimentation of a municipal water supply reservoir located on the watershed. Results of the analyses agreed favorably with measurements of sediment in the reservoir.

INTRODUCTION

Municipal water supply is a major problem in Honduras, particularly for the capital city of Tegucigalpa. The national water agency (Servicio Autonomo Nacional de Acueductos y Aleantarilladas) has plans for developing five reservoirs on watersheds near the capital. One of these reservoirs which has a planned capacity to meet about ten percent of the city's needs was constructed on one of the watersheds (Los Laureles) in 1976. The reservoir on the Los Laureles watershed is located only 5 kilometers from the city. Consequently the watershed is being heavily impacted by the activities of an imigrating population from the city as well as by those of the increasing indigenous population of the watershed. The land use activities on Los Laureles are becoming extreme examples of land use practices which are depleting many of the watershed lands in Honduras.

The accessible productive valleys of Honduras are already occupied. The alternative for the landless poor is to move up into the watersheds. Forested slopes are cleared for shifting cultivation and livestock grazing. Networks of trails are established with no regard for the erosion hazard they create. Fires are allowed to escape from fields and burn uncontrolled. Forest stands are cut indiscriminately for fuel wood. The consequences are accelerated erosion; increased flooding and sedimentation, environmental depletion and further impoverishment of the people themselves.

The Project

In order to assist in the design of programs to remedy these problems, it was thought necessary to evaluate the effects of the common land use practices in upland watersheds in order to plan and prioritize improvement programs. Information was also needed to estimate the expected life of the Los Laureles reservoir and the reservoirs planned for the future. Because the land use problems existing on the Los Laureles watershed are severe examples of those which exist on other watersheds in Honduras and because of the importance of municipal water supplies, a research project was undertaken in 1977 on the watershed to determine the impact of common land use practices and to initiate demonstration programs designed to moderate the impacts. The immediate problem was to determine the effects of these practices on soil loss and the rate of sedimentation of the reservoir. The principle land uses and cover types on the watershed are pine forests (fire climax), brush land which included areas grown to brush within the slash and burn cycle of shifting cultivation, burned forest and brush land, grazing lands, and lands under cultivation. There are three major soil groups on the watershed, those developed from volcanic brecca and basalt, from volcanic tuff and from metamorphic rocks. The watershed is steeply sloping with a range in elevation from upper divide to outlet of 312 meters.

Approach

Land use, vegetative cover, and soil maps of the watershed were prepared from aerial photos and on-the-ground surveys. Measurements of road and trail networks were also made from aerial photos. The effects of land use and watershed characteristics on soil loss and sedimentation were evaluated with runoff plots, with the Universal Soil Loss

[1]Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, Flagstaff, Arizona, May 20-23, 1980.

[2]Director of Department of Watershed Management. Corporacion Hondurena de Desarrollo Forestal (COHDEFOR)

[3]Professor Watershed Hydrology, School of Renewable Natural Resources, University of Arizona, Tucson.

Equation, and with a runoff-sedimentation computer model.

Runoff Plots

Runoff plots (6 m. x 1.5 m.) were established on 2 slopes in the 3 soil groups for each of 5 land uses. Three replicate plots were installed for each combination of soil, land use, and slope. The production of runoff and sediment was measured on 6, typical 0.1 hectare sections of roads and trails; runoff was measured with 45 cm. H-flumes, and sediment loads were determined from hand-catch samples taken during storm events.

Soil Loss Equation

A computerized mapping system developed by W. O. Rasmussen of the University of Arizona was used with the Universal Soil Loss Equation (SCS, 1978) to estimate soil loss over the watershed.

The familiar Soil Loss Equation is:

$$A = RSLCKP$$

where A = soil loss (metric tons/ha.)
SL = slope length factor
C = cover factor
K = soil factor
P = land practice

Basically the computer system for USLE combines computer maps of topography, and maps of the K and C factors for the various land uses on the watershed. The maps are grided into elements of about 3 by 4 meters, and annual soil loss is determined for each element with the Soil Loss Equation.

The K factors used in the equation were determined from the runoff plot data for the three major soil types on the watershed, and the 'C' factors were determined for each of the land use types by the SCS method. Each 3 x 4 meter element had a constant length of 4 meters and a slope that was characteristic of the location of the element on the watershed. Cropping practices were assumed equal to 1.

HYMO

A runoff and sedimentation model (HYMO) developed by J. R. Williams at the University of Texas was used to estimate the annual sediment load delivered to the reservoir. The method uses the basic soil loss equation with the exception that the energy term is defined in terms of stream discharge rather than rainfall.

Namely,

$$S = 95 \times (Q_p \times Q_t)^{.56} \times K \times C \times LS \times P,$$

where S is the sediment delivery in metric tons, Q_p is peak discharge, Q_t is total storm discharge, and K,C,P and LS are the parameters required by the USLE.

The HYMO model generates storm discharge parameters required for the calculation. It uses an SCS curve number determined in the conventional way to estimate rainfall excess. In practice, a large watershed such as Los Laureles is divided into several convenient size sub watersheds which drain into the main channels of the larger watershed. The Los Laureles watershed was subdivided into thirteen sub watersheds. The flows from the individual sub watersheds are assumed to be generated by means of a unit hydrograph of the form:

$$Q = Q_p (t/t_p)^{n-1} e^{(1-n)(t/t_p-1)}$$

where Q is discharge at time t, Q_p is peak discharge, t_p is time of peak discharge and n is an adimensional parameter. The above equation is valid for the ascending and peak discharges. For discharges during the recession limb of the hydrograph, a separate calculation was used:

$$Q = Q_0 \times e^{(t_0-t)/K}$$

where Q_0 is discharge at the beginning of recession flow, t_0 is the time to the beginning of recession flow and K is the recession constant in hours. At a time t_1 equal to t_0 plus twice the recession constant, K, a new recession constant, K_1 is defined equal to three times the previous recession constant and discharge, Q, is defined as:

$$Q = Q_1 \times e^{(t_1-t)/K_1}$$

Once the unit hydrograph is calculated for a particular sub watershed, it is convoluted with the excess rainfall to yield the resultant outflow hydrograph from the sub watershed. A routing equation is then used to carry the flood wave along the main channels. The routing equation utilizes travel times computed from stream sections and water surface slopes within a stream reach. Where several sub watersheds unite, the program combines the flows into a new hydrograph.

Results and Discussion

Sediment production from the various land uses are given in Table 1. With the exception of roads and trails results were obtained with the USLE which was calibrated with the data from the runoff plots. The data summarized are the proportions of soil loss, calculated with the USLE, which would be transported to the reservoir. This delivery ratio was determined with a relationship developed by Roehl (1962).

Table 1.--Sediment production on Los Laureles watershed by type of land use

LAND USE	AREA	SEDIMENT
	- Percent -	
Roads and trails	2	45
Hill cultivation	13	20
Grazing lands	20	20
Burned forest lands	10	4
Brush lands	20	1
Forests	35	<1

The results presented on roads and trails are the extropolation of a relationship developed between rainfall and sediment production as measured on the gauged sections of the roads and trails. It was assumed that all sediment produced was transported to the main channels of the watershed. This assumption is believed not to cause great error since drainage culvents on developed roads discharge into natural channels, and since most of the foot trails are steeply sloping and run roughly parallel to the slope. In fact, it was apparent that nearly all of the gullys on the watershed originated with foot trails.

Because of the obviously serious soil depletion caused by trails, a program of trail construction and repair was undertaken on Los Laureles. A crew of forty workers was assembled for this purpose. Each member of the crew was employed 20 hours per week. Part time work was believed necessary in order to spread limited funds to a larger number of the watershed inhabitants; to provide training to a maximum number of people; to allow time for the crew members to work their small farm plots; and to prevent them from becoming to dependent upon a source of income which might not be sustained. During the second year of the project over 30 km. of trails were repaired by these crews.

Hill cultivation contributed the greatest quantity of sediment on a unit area basis. Hill cultivation in Honduras is almost always practiced on lands which are, from an ecological standpoint, better suited to forests. Indeed, most of these lands are classed as forest lands. However, in Honduras as in other countries of Central and South America, hill cultivation must be incorporated into the multiple use of forest lands. Social pressures are too great to perform land use planning simply on a basis of most suitable or highest potential use. Accordingly, a social-forestry department was created in COHDEFOR to work with the inhabitants of the watersheds of Honduras. Their goal is to incorporate the needs of these inhabitants into the forest system both by employment in forest industries such as naval stores, fuelwood plantations and agroforestation. Extension in soil conservation and crop production on hill farms is an important part of the program. The Los Laureles watershed because of its proximity to the capital and because of the research base established is being made a primary demonstration area.

There are no reliable estimates of the extent of forest land grazing for Honduras, but it is known to be excessive in many of the upland areas of the country. From the evidence found in this project, overgrazing could rank above burning as a detremental land use. Forest-range management programs have not yet been put on an operational basis in the country. The evidence gained in this project may be used to justify such programs.

The effects of forest burning appear not to be great, somewhat less than half those of grazed lands on a unit area basis. However, over two thirds of Honduras is in forest or brush lands. The bulk of these lands are on upland watersheds which are not so heavily impacted by hill cultivation and other human activities as is Los Laureles. Thousands of hectares of these lands are burned annually. Country wide (were these limited data to be extrapolated) the soil loss due to burning of forest lands would exceed that due to hill cultivation. Despite an extensive fire control system the problem has not been completely solved.

It is not surprising that forest and brush lands produce neligible downstream sediment. It could be inferred from the data that soil loss alone would not be justification for large scale forest improvement programs (eg. forest management, brush land conversion, etc). However the national economy is heavily dependent upon the export of forest products, primarily saw timber and pulp wood. Plans have been underway to establish an extensive pulp industry within the country. Thus, improved forest protection, management and utilization remain the primary objectives of COHDEFOR.

Validation of Results

The results, according to the USLE, indicate that sediment production from Los Laureles would amount to approximately 56,000 metric tons during a year of average rainfall after a delivery ratio is used to reduce the amount of sediment produced (soil loss) to that actually delivered to the reservoir.

Results of the HYMO model indicated a higher amount of 72,000 metric tons per year. The HYMO model is a lumped parameter model. That is, the K, C, and SL factors are averaged over each sub watershed. Individual land uses cannot be separated out on an aerial basis.

In order to check these estimations, a sediment survey of the reservoir was made during the dry season when the sediment deposited at the reservoir inlet was exposed. The average depth of the deposit was determined by excavating 20 pits in the area. Assuming one metric ton per cubic meter, the survey indicated that sediment deposited

amounted to 61,000 metric tons per year. The very close agreement with the estimated values was encouraging considering the errors inherent in the methods.

When the Los Laureles reservoir was constructed only the roughest estimates could be made of sedimentation rates and the expected life of the reservoir. The data from this study indicates that half the capacity of the reservoir would be lost in 60 years under present land use practices. Good sites for reservoirs are limited. With ever increasing demands for potable water by the capital and the expected increased human impact on the watersheds operational programs that can incorporate the multiple uses of watershed lands, particularly the social aspects of these uses, must be developed. It is hoped that the results of this small study can help in this development.

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LA APLICACION DE INVESTIGACIONES DE USO MULTIPLE EN LAS CUENCAS DE HONDURAS

Los efectos de las prácticas típicas de aprovechamiento de la tierra sobre la erosión de suelos de las cuencas de tierra alta de Honduras fueron estudiados en una cuenca de 270 kilómetros cuadrados situada cerca de la capital de Tegucigalpa. Los datos reunidos fueron analizados por la Ecuación Universal de Pérdida de Suelos y con el Model Hidrológico (HYMO) para determinar la proporción probable de sedimentación de un depósito o embalse municipal de aprovisionamiento de aguas situado en la cuenca. Los resultados de los análisis concuerdan favorablemente con las medidas del sedimento en el depósito de aguas o embalse.

APPLICATION DES RECHERCHES SUR L'USAGE MULTIPLE DANS LES SURFACES DE CAPTATION D'EAU EN HONDURAS

On a étudié l'utilisation typique du sol et ses effets sur l'érosion du sol dans les bassins de hautes terres de l'Honduras. Ces effets ont été étudiés dans un bassin de 270 km^2 situé près de la ville capitale de Tegucigalpa. Afin de déterminer le taux probable des sédiments déposés dans un réservoir de distribution municipale des eaux situé dans le bassin, on a analysé les données recueillies par moyen de l'Equation universelle de la perte de sol (Universal Soil Loss Equation) et d'un modèle hydrologique (Hydrologic Model). Le résultat de ces analyses est en bonne concordance avec les mesures des sédiments dans le réservoir.

DURCHFUHRUNG VON VIELFALTIGER NUTZUNGSFORSCHUNG IN WASSEREINZUGSGEBIETEN VON HONDURAS

Der Einfluss typischer Landbenutzungsmethoden auf die Erosion in den Wassereinzugsgebieten des Hochlandes von Honduras wurde anhand eines 270 km^2 grossen Einzugsgebietes in der Nähe der Haupstadt Tegucigalpa untersucht. Die erhaltenen Daten wurden nach der Universalgleichung für Erdverlust und einem Hydrologischen Modell (HYMO) analysiert, um den mutmasslichen Grad der Sedimentierung eines auf diesem Einzugsgebiet gelegenen städtischen Wasserreservoirs zu ermitteln. Das Ergebnis der Analyse stimmte in hohem Masse mit den Sedimentmessungen im Reservoir überein.

How We Use the Principle of Multiple-Use Forestry in Belgium[1]

Pierre Gathy[2]

Almost all Belgian forests are multiple-use forests; they may fulfill some or all of the possible uses. All Belgian forests are likely to be used for research. They are proof that all functions are compatible, provided: the forest is well known and soundly managed, foresters show understanding towards the public, and the public is disciplined. An important point must be kept in mind: the forest must remain productive of wood and money; they are often the very condition of its existance.

INTRODUCTION

Belgium is a small (7.5 million acres) country with 10 million inhabitants. In spite of its dense population, which is mainly industry-directed, forests cover about 20% of its territory. Historical reasons, linked with property statutes, have allowed relatively large forest areas, mainly in the south of the country (maximum elevation: 2,300 feet). Weather conditions are favorable to a natural forest vegetation, which is mainly composed of broadleaved species (oak, beech, maple, ash, hornbeam, alder, birch, wild cherry).

The forest is an important part of the life of the Belgian people. The notion of "multiple-use" is not as new in Belgium as it is in newly civilized countries with large forest reserves that can be exploited. The conscious awareness of the principle is probably rather recent, however.

At the beginning of the 19th century, famous forestry schools were founded in neighboring countries, like those of Nancy in France and Friburg in Germany. At the same time, the Belgian teaching in Gembloux brought to light the various functions of the forest: production of wood and other materials (tan bark, resin), protection of physical environment (air, soil, water), public recreation. Because of the increasing complexity of life and the evolution of society, the landscaping and scientific functions of the forest have been specified in the last 20 years. It is clear that they had already been taken into account by forest managers, however.

Function of production

The total use of wood in the country is twice as important as its own production. The determination to produce wood for the economy of the country materialized in two ways: first, forest areas were greatly increased by afforesting bare and previously cultivated lands, and private forests threatened with clearing were bought back by the State. So the area of forests increased from 1,125,000 acres in 1850 to more than 1,500,000 acres in 1960.

A second way was to intensify the production per acre: these afforestions were made with imported coniferous species, mainly Norway spruce, Scots pine, black pine, Douglas-fir, and larch. Large areas of degraded forests such as coppice, poor beech forests, and heaths have been converted into coniferous forests. Today there are only a few thousand acres of coppice left (5%), 45% of forests are very productive conifers, and the last 50% are productive broadleaved trees of a very good quality. The result is a production of 1,6 m^3 per acre, which is almost the highest in Europe, next to the Danish forest.

This important production is the result of the strenuous work foresters have been doing for 150 years. At the end of the 19th century, research workers of the "Station de Recherches des Eaux et Forêts" in Groenendael planted arboretums where they tested the behavior of new species, and where they compared their respective growth in the various parts of the country. Many experiments comparing races and origins have also been done in Belgium (as in France and in Germany) so as to determine the most productive origins for each species. Belgium has joined in all the international experiments of IUFRO for 100 years. Moreover, forest genetics has been studied for more than 30 years in many research institutes such as the "Station de Biologie Forestière" in Bockrijk and Groenendael Station.

The conclusion of these studies is that production can be substantially increased insofar as the genetic material is well known and seed orchards promoted.

Intensive research on the *Populus* genus led to a clearer knowledge of the old clones and to the creation of very productive and disease-resistant new ones ("Centre de Populiculture" de Gramont).

[1] Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.

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Another type of research deals with the productivity of species and the setting up of yield tables as well as dendrometric tables. Inventory methods have been established by the "Centre d'Ecologie forestière et rurale de Gembloux". Advanced studies have been made on so-called "secondary" species, which produce quantities of quality wood, particularly ash, wild cherry, maple, and red oak.

Finally -and we certainly haven't exhausted the subject- let's mention the numerous works dealing with cultural techniques to be applied to stands: most striking are the results of comparisons between various types of thinnings, which brought to light the effect of heavy thinnings on yields and profits (University of Louvain, Faculté de Gembloux, Bockrijk, Station de Groenendael).

Experiments on mechanization and on the promotion of forest work are being done by the "Centre Wallon du Bois" in Saint-Hubert. Note also that there exists a "Commission Nationale du Peuplier". This commission is made up of research workers, producers, and timber users who attempt to define a policy for this particular rapid-growth species.

In parallel with these works dealing directly with forest species, elaborate research has been done by the Brussels University and the "Station de Groenendael" on the forest ecosystem and all its components. The total productivity of a forest, the quantification of its biomass, of its numerous cycles--including plants, animals, minerals, air, water, soil, and energy flow--are certainly very useful to foresters, wood producers, and research workers in other fields. Antwerp University started a thorough analysis of poplar stands.

To conclude we can say that the first aim of forest policy in Belgium is the production of quantities of quality wood, of diversified species in adequate stations, so as to best satisfy the national economy.

Thanks to this favorable atmosphere toward forestry, Belgian laws are not constraining. Except for the "Cadenas Law" which limits eventual exploitation excesses, but has seldom been applied, no measures affect private forests. State forests and Public Collective forests fall under the 1845 "Code Forestier". This fundamental law has allowed for good protection of forests and efficient management of them.

Since 1962, a new law exists concerning the "Aménagement du Territoire et l'Urbanisme". Forest zones considered as more natural or more social have been defined as such and, normally, can no more be modified.

Physical functions of the forest

The traditional functions of the forest as a regulator of weather extremes, a regular supply of pure water, and a security against erosion, are parts of the "genetic knowledge" of any forester.

Research on water use and the effect produced by various species led to the conclusion that coniferous trees need about 8 to 15% more water per year, but that they produce twice as much wood and five times more money.

However the constraints of population density, the modern way of life, city-planning, and the creation of industrial areas, have led to a new concept of the physical role of forests. Reduction of noise intensity, gas and air dust collecting, oxygen production by photosynthesis, physical and psychological need to hide ugliness, all these are now justifications for keeping forests where they exist, and for creating forests were they are lacking. Thorough research has shown that forest screens should be of mixed and varied rapid-growth species, with shrubs and, if possible, grasses. They pointed out the critical role of borders.

The forest often appears to be an easy and cheap way of hiding the deficiencies of rushed city planning. It helps to create an agreeable working environment. Industrialists frequently consult foresters to ensure a quality urban or industrial environment. The "Centre de Biologie Forestière" of Bockrijk showed a special interest in the "green" aspect of industrial zones. They even suggested the creation of ecologic forest zones in industrial areas. The width of these forest screens varies according to the various environment contingencies, the species chosen, the price of the land, etc., but they will be a minimum of 30 feet. These "ecologic zones" and artificial forests often become recreation zones for the people living nearby.

Social functions of the forest

People in general consider the forest as a place of recreation, open to the public on foot, on horse, on a bike, or on skis. However, we must remember that this opening of the forest to the public is a rather new thing. In the Middle Ages rural people wandered very often through the forest, either to pick up wood or to feed their cattle or simply to go from one village to the other. The conditions of life have changed, and this type of wandering has been replaced by that of the simple wanderer, of the sportsman, of the photography amateur, of the people around a barbecue. The damages to the forest are not worse now than they were a hundred years ago; quite the contrary. If the public is somewhat well-schooled, doesn't walk off the paths, dosen't light fires, and especially if it understands the living conditions of the forest, the latter is not in danger.

Specific equipment such as paths, riding and cycling tracks, rest places and barbecues, adequate road signs, shelter places with maps and recommendations, all these are means to limit the damage to the forest ecosystem. Recent research in the Sart-Tilman forest shows that the trampling of horses leads to a real loss of growth for trees: for example, the loss of 1.5 FB the running meter due to the creation of a 9-foot-wide riding track in a stand of Norway spruce.

Numerous sociological surveys show that the public in general looks for quietness in a clean forest; heavy equipment is required only by a minority of people.

It seems that the most noticeable effect of the public in the forest is upon animals and game. Quietness is most important in the life of wild animals. Noise, dogs, approaches of photographers or observers, generally at crucial times in the life of game, lead to a decreasing fertility of the pairs and disappearance of animals. Either they seek peace elsewhere, or they get killed by cars on the roads.

It has been proved that pairs of wood grouse become sterile if they are disturbed during their love dance. Numbers of roe-deer are killed on the roads: in the Sart-Tilman forest, 24 roe-deer were known to have been killed by cars in two years, in about 2,500 acres of forests. Of course, a number of others died unknown. The initial population of roe-deer was about 50.

In the frame of this social function, we shall include hunting. Hunting is as old as humanity. Before, however, game was something man could live upon or at least, complement his food. Hunting has progressively become a means of recreation. Stag-hunting as in the Middle Ages is only practised once in a while in Belgium. Shooting, either stalking or in "battue", has become more frequent. Many city-dwellers find in it an opportunity to walk in the forest, to get to know it better, to respect it, to entertain themselves in the company of friends. Hunters pay very much to have the right to shoot; they are bound by very strict laws.

Moreover, studies on game behavior, on the evolution of populations, on the quality of trophies, as well as on the relations between game, beasts of prey, and the forest environment in which they live have led to the elaboration of shooting plannings to which hunters are bound. Generally they are willing to respect the rules. The research group on Forest-Game Equilibrium and the "Station de Recherches des Eaux et Forêts" have been working a long time on this subject so as to improve game and integrate it as well as possible into a balanced and productive forest, in which regeneration is still possible and the trees are not damaged by game. More and more, in Belgium, hunting grounds are scientifically managed and the results are felt on the quality of the game and the perenniality of the forest.

It is interesting to underline that hunting has often been and is still very often the main reason for the keeping of certain forests, and for their supervision. Belgain legislation on hunting is getting more and more restrictive: the aim is doubtless to respond to the pressure of public opinion so as to save certain animals. But as far as big game is concerned, the question is to ensure a better plant-animal equilibrium.

Scientific and educational functions

All Belgian forests, but mainly forests adjoining big cities, are specifically open to observation and scientific research. Examples include the "Forêts de Soignes" in Brussels (11,250 acres), "Sart-Tilman and Vecquée" forest in Liège (5,000 acres), as well as forest areas set at the disposal of Universities of Agriculture and Forest Faculties, such as "Meerdael and Héverlée" forests in Louvain, the "Forêt des Epioux" in Florenville (4,500 acres), the "Bois de Gontrode" in Gand, and other smaller Forest areas.

Research workers, university students, primary and secondary school students, various groups, and associations find there many subjects for botanical, zoological, geological, pedological, and ecological studies.

In a small country like Belgium, the forest appears as the last refuge of wildlife. Very often it turns out to have sheltered remains of our ancestors' life: Middle Ages hewed silex, Gallo-Roman traces, Middle Ages stone heaps, all these emphasize a historical funtion.

Observation of forest life is linked with an educative action. Every group of young people who has an opportunity to walk through the forest and understand it, either thanks to a competent guide or simply to explicit road signs or booklets, will have a new attitude towards nature. This attitude will have, without any doubt, an impact on the behavior of that man with his fellow men. The experience we have been living for 20 years at Sart-Tilman is conclusive on this point. The efforts we have been making to explain the forest and the work of the forester were certainly rewarded: tree damage, littering of the forest, chasing of animals, all were reduced whereas the number of people walking through the forest has greatly increased.

Here we should underline the necessity to use the media as often as possible: press, television, radio are very useful services. The forest is thus an effective educative means but, however, seems to be the first to draw any profit from this educative action.

The natural reserves created in Belgium by the State and various private associations belong to that educative and scientific function. Generally they are particular landscapes such as moors, rocky slopes, pools, and marshlands. However a number of forest areas are protected in order to preserve

specific animals or plants, or geologic or historic sites.

The law on Nature Conservation, passed in 1973, established the Forest Reserves; they are national forests with a relatively natural composition and structure treated in a way such as to keep or reinforce those characters.

Esthetic function

In an old civilization, densely inhabited and cultivated, forests play an important part as a structuring element in the landscape. Poplars in Low and Middle Belgium, small broadleaved forests in the Condroz, large forests with beautiful borders of beech or spruce around cultivated glades in the Ardennes, all these elements give the landscape a balanced and typical character. Studies to quantify the value of landscapes award high marks to forests and trees.

Nowadays, before every regrouping of agricultural lands, a study of landscape is done which generally shows the necessity to keep a few "strong points" such as trees, borders, forests, hedges. Moreover these elements offer other advantages in the landscape: reduction of wind and evaporation in cultivated areas, shelters for game and various animals, production of wood for local use. The balancing function of the forest must then be strongly considered.

In urban and industrial zones we also note the important part forests can play in the restoring of industrial tips, abandoned quarries, and various dumps. As a matter of fact, Belgian legislation has been prescribing these reafforestings since 1911.

CONCLUSIONS AND SUMMARY

We can affirm that almost all Belgian forests are multiple-use forests. Some of them are effectively organized as such: they are mainly suburban forests (Sart-Tilman, Hévérlee, Soignes, Loverval), and a number of national forests ("Grand Bois" in Vielsam, "Bois du Roi" in Winenne, "Forêt des Epioux", "Pijnven"). The others fulfill all the functions described in this paper, or part of them. In fact, certain forests or parts of the forests belonging to private or even public owners may be closed to the public either permanently or temporarily. Thus an important function seems not to be fulfilled, but generally to the profit of the others: a more intensive production of wood, a more reasonable and more efficient organization of hunting, the more serious protection of a particular biotope, the conservation of a research or demonstration field.

In any case, all Belgian forests are likely to be used as research fields for either of the considered uses... They are a proof that all functions are compatible provided that the forest is well known and soundly managed, provided that foresters show understanding towards the public and that the public is disciplined.

An important notion must be kept in mind: the forest must remain productive of wood and money. It is often the very condition of its subsistence.

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APPLICATION DU PRINCIPE DE LA FORET A USAGES MULTIPLES EN BELGIQUE

Nous pouvons affirmer que pratiquement toutes les forêts belges sont soumises depuis longtemps à la conception des usages multiples. Certaines sont aménagées effectivement dans ce sens : il s'agit essentiellement des massifs forestiers suburbains (Sart Tilman), Héverlée, Soignes, Loverval, par example), de certaines forêts domaniales (Grand Bois à Vielsam, Bois du Roi à Winenne, Forêt des Epioux, le Pijnven par exemple).

Les autres remplissent toutes les fonctions décrites dans cette note ou une partie de ces fonctions. En effet, certains massifs forestiers ou parties de massifs appartenant à des propriétaires privés ou même publics peuvent être fermés de manière permanente ou temporaire au grand public. Une fonction importante semble alors ne pas être remplie : mais en général c'est au bénéfice d'autres fonctions : la production de bois plus intensive, la gestion de la chasse plus raisonnée et plus efficace, la protection plus ferme d'un biotope particulier, la préservation d'unchamp de recherche ou de démonstration.

Toutes les forêts belges sont en tous cas susceptibles de servir de terrain de recherche pour l'un ou l'autre des usages considérés... Elles sont la démonstration que toutes les fonctions sont compatibles moyennant une bonne connaissance du milieu forestier, une saine gestion et de la compréhension de la part des forestiers et une discipline intelligente de la part du grand public, depuis le cherchur scientifique, jusqu'au simple promeneur, en passant par le chasseur, le cavalier, l'automobiliste.

Mais une notion importante à retenir est que la forêt doit rester productive de bois et d'argent : c'est souvent la condition même de sa subsistance.

APLICACION DE LA NORMA DEL BOSQUE CON ENPLEO

Podemos afirmar que casi todos los bosques de Bélgica son sumiso a concepciones de empleos múltiples. Algunos son acondiciondados, en efecto, de ese modo : se trata esencialmente de bosques suburbanos (Sart Tilman, Hévérlée, Soignes, Loverval, por ejemplo), de algunos bosques del govierno (Grande bosque de Vielsam, Bosque del Reis en Winenne, Bosque del Epioux, el Pijnven por ejemplo).

Los otros rellenan todas las funciones descritas en està noticia o una parte de esas funciones. En efecto, algunos bosques o partes del bosque que pertenecen a dueños particulares o publicos, pueden ser serado de modo permanente o temporario al grande publico.

Una funciÓn importante no parece entoce ser desempeñada : pero en general es con el benefico de otras funciones : la producciÓn de un monte mas intensivo, la gestiÓn de una caza mas razonada y mas eficaz, la protecciÓn mas firme de una zona biolÓgica particular, la preservaciÓn. Todos los bosques de BÉlgica son, de todos modos, susceptibles de servir de terreno de investigaciones, para uno o otro empleo considerable... Ellos son la demostraciÓn que todos las funciones son compatibles con un buen conocimiento de un medio forestral, una sana gestiÓn y una disciplina inteligente de la parte del grande publico desde el investigador cientifico, hasta el simple paseante, pasando por el cazador, el caballero, el automobilista. Pero la nociÓn importante que tenemos que retener es que el bosque tiene que quedar productivo de madera y dinero : es siempre la condiciÓn misma de su subsistencia.

ANWENDUNG DES PRINZIPS DER VIELFALTIGEN BENUTZUNG DES WALDES IN BELGIEN

Wir können sagen, dass praktisch alle belgischen Wälder seit lange schon vielfältig benutzt werden. Einige davon sind eigentlich dementsprechend eingerichtet : hauptsächlich sind es die Vorortswälder (Sart-Tilman), Héverlée, Soignes, Loverval, z.B.), und einige Staatswälder ("Grand Bois" in Vielsam, "Bois du Roi" in Winenne, "Forêt des Epioux", "Pijnen", z.B.).

Die anderen besitzen alle, oder nur einige der hier oben beschriebenen Funktionen. Einige Wälder oder Waldteile, die privaten oder öffentlichen Eigentümern gehören, können nämlich dem Publikum ständig oder nur vorübergehend geschlossen werden. Eine bedeutende Funktion scheint dann nicht erfüllt zu sein; aber im allgemeinen zugunsten anderer Funktionen ; der intensiveren Holzerzeugung, einer überlegteren und wirksameren Jagdverwaltung, des kräftigeren Schutz eines besonderen Biotops, der Sicherung eines Forschungsoder Vorführungsfeldes.

Alle belgischen Wälder sind jedenfalls geeignet, um als Forschungsfeld für eine und die andere der betrachteten Benutzungen zu dienen. Sie beweisen, dass alle Funktionen vereinbar sind ; vorausgesetzt sind nur eine gute Kenntnis des Waldmilieus, eine gesunde Verwaltung, Verständnis von Seiten des Publikums, vom wissenschaftilichen Forscher bis zum einfachen Spaziergänger, über den Jäger, den Reiter und den Autofahrer.

Feststeht, dass der Wald Holz und Geld eraeugend bleiben soll. Nur so wird er am Leben bleiben können.

Integrated Research in Forestry Resources[1]

Mahmood Iqbal Sheikh[2]

Abstract.--Forests, watersheds, and grazing lands, the important renewable resources of Pakistan, are highly depleted. Silvicultural investigations have mainly been focused on introduction of fast-growing tree species, development of cultrual methods, selection of species for growing in arid and semi-arid lands, developing methods of regenerating forests, and water requirements of species. Work has also been started on growing trees with farm crops. To find out why afforestation measures in watersheds are not reasonably successful, researchers are studying the socio-economic condition of the people.

INTRODUCTION

The major objective of a forester in Pakistan is to produce optimum sustained benefits for the people from the country's renewable resources: forests, grazing lands, and watersheds. Unfortunately, the present state of these resources is highly unsatisfactory. Due to unrestricted cutting of trees and shrubs and relentless pressure of grazing, watersheds have been denuded. The result is unregulated flow of water and excessive loss of soil. This situation not only makes reforestation quite difficult, but also causes dams to become silted full so that floods have become a regular feature. The research programme, therefore, must focus primarily on the improvement of these areas, and ways and means to make them fully productive.

PLANTING CONTAINERIZED CHIR PINE

In the mountainous regions of Pakistan, past reforestation efforts relied largely on natural regeneration. Because cattle grazing is difficult to control, natural regeneration was scarce. Site conditions deteriorated seriously. About the only method of regenerating forest areas was to sow the seed and wait hopefully for germination and survival of seedlings against heavy odds. The results were far from satisfactory.

Recently, researchers tested planting of 2 to 3-year-old containerized seedlings of chir pine (Pinus roxburghii) survival was almost 90% (12). It has proved to be a very useful innovation.

Success in the chir pine zone has encouraged use of containerized planting stock in the moist temperate forests for large-scale planting of Cedrus deodara. Techniques were also developed for reintroduction of broad-leaved associates such as walnut, oaks, and bird cherry, which were fast disappearing due to intensive harvesting (13).

All these forests are on the summer and winter routes of nomadic graziers, who play havoc with the vegetation.

Also, chir pine is the only source of oleo resin in Pakistan. Currently only half of the demand is being met from local sources. Use of 40% sulphuric acid in conjunction with the American bark hack method, started about 6 years ago, doubled the resin yield over the century-old French method of tapping, which yielded less than 2 kg of resin per tree (11.17). The new technique has gradually been accepted by field foresters as a tool to increase resin production.

However, it was realised that unless the socio-economic factors chiefly responsible for deterioration of the watersheds were understood, new techniques learned in reforeststion would be of little help. A survey indicated that the land owners were not entirely against planting of trees: they only feared that their cattle would be banished from the land, which would ultimately become the property of the government. Their very survival depends on the few quintals of corn they manage to harvest from their small holdings, and the sheep and goats they rear.

Successful demonstration plantations of the property of certain progressive farmers was enough to attract the attention of other farmers. Keeping the animals away only for one season allowed the

[1]Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.
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trees to get established, and lush green nutritious grasses appeared. Seeing this advantage, quite a few farmers offered their land for planting of forest and fruit trees. The only restriction was that they were not to let their animals loose in afforested areas; they could cut the grass and stall feed them. Under the U.N. World Food Programm, they were provided food for themselves and feed for their cattle for the services rendered in the project. Thus a break-through in afforestationmethods, coupled with an increase in the yield of resin and study of the socio-economic conditions, has opened the way for the largest ever tree planting program in the watersheds of the country.

PLANTING TREES WITH CROPS

Poplars were introduced in Pakistan about 20 years ago. Over a period of time nursery and field planting techniques have been perfected (1, 4, 8). The most outstanding success of silvicultural research has been the acceptance of poplar by the farmers of Frontier Province and Northern Punjab. They are not only growing poplars as windbreaks to protect their fruit orchards and farms from cold winters and hot summers, but they are also planting the tree with agricultural crops. One tree after 5 years (6 inches diameter, 38 feet high) returns Rs. 100 to 150.[3] In the Punjab, turmeric, wheat, and clover have been grown between the rows of poplar plantations for the first 2-3 years. The turmeric crops return about Rs. 20,000 per acre per annum, and a tree after 10 years brings about Rs.450/-(10).

Work on a poplar was started with only a few hybrid clones. Subsequently it was found that these clones were not suited to the different climatic conditions throughout Pakistan. More clones were therefore imported and tested. A study to compare the rate of growth of six different clones showed *Populus deltoides* I-63/51 gave the best performance followed by *P. euramericana* I-214, *P. deltoides* I-69/55, *P. deltoides*, I-18/62 (9). These clones are now being distributed to the farmers.

To determine the best spacing at which poplars should be planted, a study was started with seven spacings, 6x6 feet to 18x18 feet, with 2 feet interval. Seven replications over an area of 47 acres has indicated 8x8 spacing as the best for height growth and 12x12 for diameter (14).

The country is deficient in wood. Is it possible to grow trees on farm lands without adversely affecting the crop yields? A related question is; Can properly oriented tree rows increase crop yields in areas subjected to hot, dry winds? An effort is being made to find answers to these questions. In some of the agricultural areas in the country, farmers are still a bit hesitant to plant trees on their farm land. They object that trees will usurp sunlight, water, and nutrients meant for the farm crops. A study was therefore conducted to find out how far the shade of individual trees growing in the agricultural fields would affect the yield of crops. Results indicated that the maximum loos occurred within a 2-meter radius of the tree, and also that the yield was poor from the portions of the crop on the northern side of the tree. The yield continued to increase as the distance increased, the maximum being on the southeastern side of the tree (18).

Similarly in another study it was found that single and double rows of *Dalbergia sissoo* and *Morus alba* ranging in height from 5 m - 18 m growing on water channels did not depress crop yields at 2.5m distance from tree rows (15, 16). Efforts are being made to help the farmers understand that, even if there is some loss in the yield of agricultural crop by planting trees, it will be more than compensated by the sale of wood from their lots.

PROVENANCE TESTS WITH EUCALYPTS

About one hundred years ago, planting of eucalypts was started in Pakistan. Planting efforts were haphazard, and the total planted area never exceeded 500 acres. The product was considered useless due to wood splitting, shakes etc. The first improvement step was to eliminate useless species not climatically suited to Pakistan. This brought us to five or six species: *Eucalyptus camaldulensis, E. teriticornis, E. melanophloia, E. microtheca, E. citriodora.* Side by side tests were made on seed sources of the most promising eucalypt, *E. camaldulensis*. Out of 13 provences it was possible to select the best five with significantly higher rate of growth and wood yields (3). Seed from these sources is being supplied all over the country.

It was considered that water requirements of eucalypts are heavy. They were therefore raised in irrigated plantations with large quantities of water without knowing whether it was being used by the trees. Studies carried out during the last five years around Peshawar (12 inches average annual rainfall) have indicated that the tree can be grown without supplemental irrigation, and performs even better than the known xerophytes such as Zizyphus and carob (6). This new knowledge has opened large possibilities for its use in the semi-arid plains for producing firewood and round timber.

We were rather skeptical about the use of eucalyptus timber. When sawn it is notorious for splitting, irregular shrinkage, and warping. A study conducted to find out the effect of type of sawing and seasoning time on recovery and defects indicated that trees should be felled by the end of October, and immediately converted into 70 mm quarter sawn planks. Planks should be stacked in a well-ventilated room; a uniformly distributed

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[3]10 Rupees = $1 U.S.

load on the top of the stack helps reduce distortion. This procedure has produced 5-60% of the total log volume as defect-free timber. Some beautiful furniture has been manufactured from it. Since the wood is light, it can take any stain, and can be easily painted and polished (19).

MAINTAINING JUNIPER FORESTS

Juniperus macropoda forests in Baluchistan growing at 6,000 to 8,000 feet above sea level cover about 2,320,000 acres in the 250mm average precipitation zone. These forests are a distinctive part of the human environment of Baluchistan. The Juniper tract not only sustains several local tribes and their livestock, but also provides outdoor recreation to the people of Baluchistan and Sind. These forests are vanishing fast under heavy pressure of cutting and grazing. Juniper dwarf mistletoe is taking a heavy toll of the tree (20). Insect pests are further reducing the tree population (2). If this destruction is allowed to continue, the Juniper would vanish for ever from Baluchistan.

These forests are even more important as watersheds, because establishment of apple orchards in the valleys below is entirely dependent on their storage of water. Orchard establishment would not be possible if the watersheds were cleared of vegetation. The vast grazing ground which sustains millions of sheep and is the main occupation of the people of Baluchistan would also disappear.

An integrated research effort has proved to be quite beneficial. Natural regeneration of Juniper is non-existent. The first step was, therefore, to raise large numbers of seedlings. It was not easy. There is high tree-to-tree variation in the percentage of filled seed. The embryo often disintegrates as the berries mature. A break-through has finally been made and the problem solved to a great extent: The berries that are reddish in color and rather dry have 25% live embryos, while berries that are black, ripe, and juicy have hardly 10% live embryos.

In addition to Juniper, thousands of plants of local species of economic importance such as *Ephedra nebrodensis* and *Fraxinus xanthoxyloides* have been raised and planted. *Cuppressus arizonica* and *Gleditschia triacanthos* have been successfully introduced. Based on the preliminary studies on runoff and availability of palatable grasses and forbs, a coordinate program with specialists and watershed and range management has been started (5). Recovery of range vegetation would also help the survival and multiplication of wild herds of Markhor *(Capra falconeri)*, Ibex *(C- hircus)* and "gad" *(Ovis orientalis)*. These forests also provide excellent shoot of Chikor.

DETERMINING WATER USE BY TREES

Canal water is a precious commodity in Pakistan. Agriculture has prime rights to it. Irrigated tree plantations in Pakistan were started about 115 years ago. Inspite of such a long practice of raising trees with canal water, water requirements of important tree species planted in the area are not known. In a preliminary study on water requirements of *Dalbergia sissoo*, it was found that much more water was being applied than was necessary for optimum growth (7). To find out the optimum requirement of other tree species, namely *E. camaldulensis*, *Salmalia malabarica*, *Morus alba*, and poplars, a study has been started using three different depths of irrigation water--viz. 3, 4.5, and 6 feet--in one irrigation season, in five replication over an area of 21 acres. The results should give us a good indication as to how much water we should actually give these trees; the rest of it can be saved for agriculture.

RESEARCH MUST BE APPLIED

All research in Pakistan has to be production oriented. Before starting a project we must ask ourselves: Will the solution of the problem make the country more productive, and will it be practical to apply the results in the field. Without such foresight it would be difficult to provide an answer to the searching questions now frequently being put to researchers.

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LAS INVESTIGACIONES INTEGRALES DE LOS RECURSOS FORESTALES

Pakistán es una tierra de muchos contrastes. Empezando con los desiertos vastos casi improductivos fronterizos al Mar Arábigo, el paisaje se dirige a los pastos alpinos. En medio está la cuenca Indo con tierras agrícolas ricas, el bosque espinoso tropical, los bosques ribereños, plantaciones regadas hechas por el hombre, el bosque de chaparral y los bosques templados secos y húmedos. Los recursos renovables importantes de Pakistán--bosques, cuencas hidrológicas y tierras de pasto--están en una condición sobreexplotada. Las investigaciones deberían, por lo tanto, enfocar claramente la obra de restituir el potencial de tales áreas para hacerlas más productivas. La diversidad de condiciones climáticas, bióticas y edáficas ha hecho muy difícil la preparación de un plan viable de operaciones. El desafío a los investigadores es formidable, pero sin embargo, algún trabajo provechoso está en progreso. Investigaciones silvícolas se han enfocado en la introducción de especies de árboles de crecimiento rápido, desarrollo de métodos de cultivo, selección de especies para criar en terrenos áridos y semiáridos, desarrollo de métodos de regeneración de bosques y de requerimiento de agua de las especies, etc. También se ha iniciado estudios para resolver si los árboles pueden ser cultivados junto con cosechas agrícolas. Se enfatiza las especies promisorias de árbol y se estudian todos los aspectos de su propagación y utilización. Con el fin de resolver por qué los medios de plantación de los bosques en las cuencas hidrológicas no tienen el éxito esperado, los investigadores están coleccionando datos sobre las condiciones socio-económicas. El ampliar la base técnica parece proveer una respuesta al problema.

INTEGRIERTE FORSCHUNG ANF DEM GEBIET VON FORSTPRODUKTEN

Pakistan ist ein Land vieler Gegensätze. Beginnend mit den unendlich grossen, meist unproduktiven Wüsten, die an die arabische See grenzen, führt die Landschaft bis in die alpinen Weiden. Dazwischen liegt das Induseinzugsgebiet mit reichen landwirtschaftlichen Böden, die tropischen Dornenforsten, die Wälder entlang der Flüsse, bewässerte Plantagen, Buschwälder und trockene und feuchte Wälder der temperierten Zone. Wälder, Wassereinzugsgebiete und Weideländer, zusammen die wichtigen, erneuerbaren Naturschätze von Pakistan, befinden sich in einem sehr dürftigen Zustand. Deshalb sollte die Wissenschaft scharf die Aufgabe der Wiederherstellung des Potentials solcher Gebiete in's Auge fassen und sie produktiver machen. Die Unterschiede im Klima, der biotischen und edaphonischen Verhältinisse hat die Aufstellung eines wirksamen Aktionsplanes recht schwierig gemacht. Die Aufgabe ist deshalb für den Wissenschaftler sehr schwierig, aber nichtsdestotrotz ist einige nützliche Forschung im Gange. Die waldbauliche Forschung war vor allem auf schnellwachsende Baumspezies ausgerichtet, Entwicklung von Anbaumethoden, Auswahl von Arten, die in Wüsten sowie Halbwüsten wachsen können, Entwicklung von Forstverjüngungsmethoden und Wasserverbrauch verschiedener Spezies, usw. Untersuchungen begannen auch, herauszufinden, ob Bäume zusammen mit Landwirtschaftlichen Produkten wachsen können. Der Schwerpunkt liegt bei den meist erfolgversprechenden Baumarten. Alle Aspekte ihrer Fortpflanzung und Nutzbarmachung werden erforscht. Ausgerichtet, herauszufinden, warum Aufforstungsmassnahmen in den Einzugsgebieten nicht einen angemessenen Erfolg haben, sammeln die Forscher Kenntnisse über die sozio-ökonomischen Verhältnisse der Leute. Ein richtiges Verständnis der Ursachen und Erwerbung von technologischem Wissen scheinen eine Lösung des Problems zu geben.

RECHERCHES INTERDISCIPLINAIRES EN RESSOURCES FORESTIERES

Le Pakistan est un pays de beaucoup de contrastes. Le paysage s'étend des vastes déserts pour la plupart improductifs qui touchent la mer d'Arabie jusqu'aux pâturages alpins. Entre ces deux régions se trouvent le bassin de l'Indus avec ses riches terres agricoles, des forêts épineuses tropicales, des forêts riveraines, des plantations irriguées, des forêts buissonneuses et des forêts tempérées sèches et humides. Les ressources importantes et renouvelables du Pakistan, les forêts, les eaux et les pâturages, sont bien près d'être épuisées. Les recherches devraient donc être orientées vers la restauration du potentiel de ces régions pour les rendre plus productives. La diversité des conditions climatiques, biotiques et édaphiques a rendu la préparation d'un plan d'opérations viable très difficile. Les chercheurs font face à une tâche ardue; ils ont cependant déjà commencé des travaux utiles. Dans le domaine de la sylviculture, les recherces portent sur l'introduction d'espèces d'arbres à croissance rapide, sur le dévelloppement des méthodes de culture, sur le choix d'espèces à cultiver dans les régions arides et semi-arides, sur le développement des méthodes de regénération des forêts, sur le besoin en eau des espèces, etc. Des travaux ont aussi été entrepris pour savoir si les arbres peuvent se cultiver en même temps que les cultures agricoles. L'accent est mis sur les espèces d'arbre prometteurs et tous les aspects de leur propagation et utilisation sont étudiés. Pour savoir pourquoi les mesures de boisement dans les surfaces de captation d'eau n'ont pas donné de résultats positifs, les chercheurs rassemblent des renseignements sur les conditions sociales et économiques. L'acquisition d'une connaissance technique semble pouvoir fournir une réponse au problème.

Application of Research Results of Multipurpose Forest Use in Forests with Hydrologic and Soil Protection Functions[1]

Vladimir Perina[2]

Abstract.--In central Europe, the concept of multipurpose forestry grew spontaneously out of necessity when public need for soil and water conservation became as important as timber production. A summary of axioms for use in functionally integrated forestry is given, along with a description of five soil and water conservation complexes. Economic measures which can be taken to solve some of the problems in integrating soil and water conservation functions with that of wood production are discussed.

INTRODUCTION

From the very beginning, forestry in central Europe has recognized not only timber production but other multipurpose forest functions as well, including water and soil conservation. This concept has been reflected in forestry laws enforced since the eighteenth century.

Multipurpose forestry in central Europe started with the assumption that maximum timber production and sustained yield required attention to other functions, such as water conservation and soil protection. For a time, these latter functions assumed a secondary role; this was a time when forestry (aimed at timber production) used techniques requiring little energy expenditure and little damage to the environment.

However, with the development of society in central Europe, with increased demands for natural resources, and with industrialization, the secondary forestry functions have often become the main functions or (at least) as important as the timber production function. For example, the hydrologic function of a forest has become a planned component in watershed management to ensure satisfactory quality and quantity of water for industrial and domestic uses.

At the same time, modernization of forestry and mechanization of silvicultural techniques requiring a large energy output (such as logging and timber transport) can often result in disturbance of the environment and negatively influence environmental functions of a forest. Therefore, the secondary function of soil protection has also become a major factor in many areas.

In this way, forestry in central Europe received a new dimension: ensuring other required beneficial multipurpose functions of a forest while simultaneously sustaining a well-balanced (maximum) production of biomass (Perina and Krecmer 1977). From single-purpose (timber production) forestry, where secondary functions were generally offered at random, a functionally integrated domain evolved in which environmental functions became major economic ones, being included as necessities in planned forestry activities. Under the concept of functional integration, forest planning includes not only timber production, but also environmental functions derived from public needs in a given area (Krecmer 1978).

Specifically, timber production has been functionally integrated with hydrologic and soil protection functions in forests of Czechoslovakia because of the great interest in water conservation and soil erosion prevention.

PRECONDITIONS FOR SOLUTION

World-wide forestry research has produced new information on influences of forests and their

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management on water conservation and prevention of soil erosion. Results of this research have been obtained not only from small plots, but also from larger watersheds with various natural conditions, with forests of various species composition and structure, and with various methods of forest management.

Important new knowledge has been obtained on a forest's influence upon retention, retardation, and detention of water, snow accumulation and melting, water infiltration, interception of liquid and solid precipitation, evapotranspiration, and water quality and quantity (Moltchanov 1960, Anderson et al. 1976, Fedorov 1977). When analyzing these results, we come to the conclusion that the influence of forests on the water cycle and soil properties depends on both natural conditions (climate, geology, and soil) which we cannot change significantly, and other conditions (percent of area covered with forest, tree species composition, age, and density) which may be influenced by forestry activities.

In addition to the influence of the character and quantity of forest biomass upon the water cycle and soil properties, important information has been obtained on the influence of forest management activities upon water conservation and soil erosion prevention in various parts of the world. To a large extent, this information describes effects of regeneration methods, and logging and forest transport networks on soil protection, surface runoff, and water pollution (Corbett et al. 1978, Douglas and Swank 1974, Drobikov and Ponomarev 1977, Jarabac et al. 1979, Krammes and Burns 1973, Kresl 1978, Megahan 1976, Olijnik and Tuchatyi 1978, Pobedinskii 1970).

In summarizing recent forestry research findings we come to the conclusion that hydrologic and soil protection functions of forests are influenced not only by intentional manipulation of forest stands (tree species composition, structure, age classes), but also by timber harvesting techniques (scheme of felling, wood concentration, and transport). Hydrologic and soil protection functions are determined, not only by biological but also by biotechnical and technical aspects of forestry, which are applied within functionally integrated forest management practices (Perina et al. 1973, Douglas and Swank 1976, Koval 1977).

Research results have further shown that forest management directed toward balanced and permanent production of timber does not always coincide with hydrologic and soil protection function of forests. For that reason, single-purpose (timber production) forestry cannot satisfy the increased demand by the public for environmental functions. It is here that the need for multipurpose forest management has become evident (Brechtel 1968, Kracemer and Perina 1975).

Since timber production and hydrologic and soil protection functions of forests are dependent upon natural conditions, forest management cannot be generally and without some reserve applied to all natural conditions. Nevertheless, present knowledge (obtained from recent forestry research) may be summarized into the following axioms for use in functionally integrated forestry:

1. Growth processes, soil protection, and hydrologic functions of forests are, first of all, subject to natural conditions.
2. Wood production processes, as well as hydrologic and soil protection functions of forests, may be intentionally influenced by economic measures of biological, biotechnical, and technical character.
3. The active environmental functions (in our case, hydrologic and soil protection functions) are also subject to natural conditions, and specified according to public needs and demands in a given area.
4. Economic and technical conditions of forest cultivation, which include important hydrologic and soil protection functions, are not always within the limits of economic and technical conditions of wood production. Single-purpose (timber production) forestry cannot include active environmental functions without functional integration of its economic and management scheme.
5. It is usually not possible to exclude forests with important environmental functions from intensive timber production and from the rationalization of management measures. Our endeavor is to achieve, by means of functional integration, the multipurpose use of natural resources.

POSSIBLE METHODS OF SOLUTION

Because timber production, and hydrologic and soil protection functions of forests are dependent on natural conditions, application of forestry research findings to planning for the multipurpose use of forests requires the division of geographic regions according to natural conditions. For this reason, forest typology, which stratifies a forest into types, may be applied.

As is well known, forest types characterize areas with the same or similar natural conditions (climate, geology, and soil). Through delineation of forest types, we can obtain necessary information on required hydrologic and edaphic characteristics of an area and, therefore, may aggregate forest types into strata according to requested hydrologic and soil protection functions.

Forest types can be associated with water and soil conservation complexes by the following scheme:

Complex Number	Soil and water conservation characteristics of forest types	Water and soil conservation complex of forest types
1	increased erosion of banks of streams, basins, and adjacent bases of steep slopes	water protective
2	minor (weak to moderate) potential surface erosion of soil	infiltrative
3	major (strong and very strong) potential surface erosion of soil	antierosive
4	water logged soils	water withdrawal
5	intensive catchment of horizontal fog precipitation by the crowns of stands	precipitation forming

These five water and soil conservation complexes of forest types differentiate forested areas with respect to problems which have corresponding economic measures as solutions.

1. The water protective complex includes forst types along banks of streams and water basins serving antierosive and sanitary functions. Here, emphasis is on clean water. These forests are also the place where precipitation is retained and, therefore, fulfill the function of a hygienic barrier. The hydrologic function of the complex consists of protecting stream banks and water basins against erosion, from sediments originating upstream, and from logging wastes. Its task is to prevent contamination of water and destruction of stream beds. Economic measures are taken mainly on slopes above the bank zones.
2. The infiltration complex includes forest types on plains and moderately inclined slopes (to 25 degrees) with minor potential for soil erosion. The targets of forest management consist of (1) maximizing infiltration of precipitation by forming optimum properties of raw humus and hydrophysical properties of soils, and (2) limitating the interception loss by vegetation.
3. The antierosive complex includes forest types on steep slopes (over 25 degrees) endangered by potential soil erosion, mainly after removal of the forest overstory and disturbance of the soil surface. Here, forest management is aimed at (1) preventing surface runoff, disintegration of the soil surface, and formation of sediments, and (2) achieving high values of soil infiltration.
4. The water withdrawl complex includes forest types on swampy soils, mainly at the bottom of hills. The hydrologic function consists of removing superfluous water from the soil profile. In this way, spaces between soil particles are emptied and become capable of accumulating precipitation and, thereby, retarding surface runoff.
5. The precipitation-forming complex includes forest types in localities where mountain fog commonly occurs. The hydrologic function consists of crowns of trees (mainly in older coniferous stands) trapping horizontal precipitation.

These water and soil conservation complexes, which describe important hydrologic and soil protection effects of forests, must be included in functionally integrated multipurpose forestry. Determination and then delineation of these complexes form preconditions to planning and implementation of multipurpose economic measures in forests where timber production, and hydrologic and soil protection functions are to be served.

The economic measures required by hydrologic and soil protection functions in a specific water and soil conservation complex include: formation of optimum tree species composition and density, adjustments in the rotation period, selection of the appropriate regeneration tree felling and wood concentration options, and design of efficient forest transport networks.

Tree Species Composition

Tree species composition of forest stands influences formation and decomposition of raw humus (Bonneau 1973, Wittich 1972, Tuszynski 1972), root growth in the soil profile (Vlek 1977, Holstener-Jorgensen 1968), and hydrophysical and soil protect-ve properties of forest soils (Levy 1969, Murai and Iwasaki 1975). Character of biomass, according to tree species composition, significantly affects the character of interception processes and the quantity of intercepted water (Aussenac 1969, Delf 1955, Weihe 1973, Zeleny 1979). In general, retnetion of precipitation and retardation of surface runoff is dependent upon the composition of forest stands (Moltchanov 1960, Mitscherlich 1971, Swank and Douglas 1974).

When choosing the optimum tree species composition, we start with the forest type which principally determines the number of species that may be cultivated for timber production. From the standpoint of hydrologic and soil protection functions, and considering the various water and soil conservation complexes, it is necessary in the water protective complex (complex 1) and (to a lesser degree) in the antierosive complex (complex 3) to give preference to deeply rooting, broad-leafed trees because of their ability to stabilize and protect stream banks against erosion.

In the precipitation forming complex (complex 5), conifers are more useful for increased formation of fog precipitation. Trees with high transpiration are suitable in the water withdrawl complex (complex 4). In all cases, it is necessary to simultaneously respect durability, security, and level of timber production.

Rotation Period

A rotation period specifies the time of final felling of trees for harvest. Final felling with mobile machines can affect a forest ecosystem in many ways, some beneficially and other detrimentally. Among these varying affects are increase surface runoff, decreased water quality, and an acceleration of erosion processes (Drobikov and Ponomarev 1977, Isajev 1972, Isajev 1976, Langford and O'Shaughnessy 1977). From this standpoint, the rotation period associated with the water protective complex (complex 1) and the antierosive complex (complex 3) should be extended over a longer period, if it does not disturb basic interest in timber production.

The rotation period (and the resulting tree age class allotment) have further importance for trapping fog precipitation. In central Europe, this form of precipitation commonly occurs in mature coniferous stands of mountainous zones (Krecmer et al. 1979). Prolonging the rotation period in forest areas above 800 meters increases trapping of fog precipitation (due to larger tree crowns in older trees) which, in turn, may increase the potential for surface runoff.

Regeneration Method

The method of forest regeneration is an important factor in hydrologic and soil protection functions of forests. Removal of the forest overstory in one operation (clearcutting) or in successive ones (as achieved in a sheltercut) changes input and output components of a water budget and affects the surrounding microclimate. In addition, logging and wood concentration can damage the soil surface, affect the infiltration capacity of the soil, and result in increased surface runoff and soil erosion (Bethamy 1971, Thompson 1974, Pobedinski 1976, Moltchanov 1978, Pismerov and Chanbekov 1971).

From this standpoint, clearcuts are prescribed in all of the water and soil conservation complexes except for the water protective complex (complex 1). Widths and, especially, lengths of clearcuts on slopes are chosen not only with respect to economic and ecologic considerations of tree felling and forest regeneration operations, but also with respect to the nonerosive speed of surface runoff over excessive slopes. In the water protective complex (complex 1), clearcutting is not desirable, as it cannot fulfill the sanitary function of protecting streams and water basins.

Felling and Wood Concentration Technologies

Recent data have shown that logging and wood concentration by mobile machines can unfavorably influence a water regime, especially by changing physical properties of the soil and by erosion (Steinbrenner and Gessel 1955, Hornbeck 1963, Hornbeck 1967, Pismerov and Chanbekov 1971, Drobikov and Ponomarev 1977).

In particular, wood concentration by tractors can adversely affect clearcut areas on steep slopes not covered by snow. In comparison with cable systems, wood concentration by tractors can result in more surface runoff and more damage to soil resources (Drobikov and Panomarev 1977). For this reason, cable systems are preferable to tractors in forests where water and soil conservation is important. In the water protective complex (complex 1) and the antierosive complex (complex 3), cable systems are necessary. This method of wood concentration is also prescribed in the water withdrawl complex (complex 4) because bed carrying capacity is limited for movement of tractors.

Forest Transport Network

A forest transport network influences the water regime of a watershed in many ways. Besides the precipitation which falls directly on its surface, this network can concentrate surface and subsurface wate flow to produce rapid runoff (Kresl 1978). Often, a considerable quantity of water flows directly and rapidly from roads into streams, contributing to flooding.

The quality and quantity of surface runoff, as influenced by the density of a forest transport network, is apparent by the amount of sediments generated as a result of erosion processes during heavy use of the transport network (Megahan and Kidd 1972, Zeleny 1976).

The transport network in forests that have important hydrologic and soil protection functions should be evaluated not only from the standpoint of technical and economic conditions of wood product movement, but also from the standpoint of required water and soil conservation effects. For instance, in the water protective complex (complex 1), nonstabilized roads should not be constructed, and water flowing from adjacent complexes onto road surface or in tranches should be dispersed into forest stands for infiltration into the soil. In the antierosive complex (complex 3), minimizing the magnitude of the transport network is desired; this is achieved by changing from tractor to cable techniques of tree skidding. Unnecessary transport lines of all kinds should be abolished in both complexes.

SUMMARY

All of the above economic measures are aimed at integrating hydrologic and soil protection

functions with the timber production function. Application of these measures in the multipurpose use of forests does not imply limiting timber production. Instead, it reflects increased costs for cultivation, logging, and forest transport for necessary and purposeful organization of timber production processes. It also means new costs for specific works which single-purpose (timber production) forestry does not include, such as care for water passage in stream beds, etc. In the Czech Socialist Republic, these measures are being realized in two catchment areas of a water supply basin in the Beskydy Mountains. Here, the increase in costs (as compared to average costs of single-purpose forestry of timber production) is 56 percent per cubic meter for felled timber, and 7 percent per hectare for forest regeneration. It is believed that, in the near future, the multipurpose use of forests (that is, timber production along with water and soil conservation) will be introduced to about 15 percent of the forested watersheds in Czechoslovakia.

In summary, this paper shows that forestry research needs to encompass society's present requirements of multipurpose forestry. The solution to problems evolving from these requirements is not only long-term, but difficult with respect to the broad spectrum of questions that should be answered. We estimate that the synthesis of available knowledge makes implementation of functionally integrated forestry in central Europe possible. Experience found here, together with further knowledge of multipurpose research of forests, will enable purposeful use of forests as a valuable natural resource.

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APPLICATION DES RECHERCHES A PLUSIEURS BUTS DANS LES FORETS AYANT LA FONCTION HYDRIQUE ET CELLE DE LA PROTECTION DU SOL

Avec le développement de la société lié à l'accroissement des exigences aux ressources naturelles et à l'industrialisation du paysage devient de l'économie forestière, dont le but principal était jusqu'ici la production de bois et dans laquelle les fonctions environnementales ont été fournies spontanément, une économie fonctionellement intégrée, dans laquelle on forme les fonctions environnementales d'une manière active selon des besoins concréts de la société, en tant qu'une partie de l'activité forestière conforme au plan.

Parce que dans beaucoup de pays l'importance des forêts pour l'aménagement des eaux et la protection du sol est au premier rang de l'intérêt, on s'occupe dans ce travail de l'intégration fonctionnelle de la forêt pour la production de bois, l'aménagement des eaux et la protection du sol.

Les recherches mondiales ont rassemblé, surtout pendant les deux décennies passées, toute une gamme de connaissances sur l'influence des massif boisés et leur aménagement sur le régime des eaux et la protection du sol. De leur analyse ressort que le rôle des forêts pour le régime des eaux ainsi que pour la protection du sol et influencé par les composants biologiques, biotechnologiques et technologiques de l'aménagemant des forêts. On doit mettre en valeur ces composants dans le cadre de l'économie forestière systématiquement et complexement.

Tous ces composants (la production de bois, le régime des eaux, la protection du sol) dépendent prémièrement des conditions naturelles. C'est pourquoi que la mise en valeur de la forêt à plusieurs buts éxige une répartition du territoire selon des conditions naturelles. Dans notre cas on peut utiliser pour ce but les types de forêts. On groupe ces types du point de vue de leurs fonctions dans des groupements appelés hydriques et de la protection du sol: 1. hydrique, 2. d'infiltration, 3. de la protection du sol, 4. de désuction, 5. de la formation des précipitations. Ces 5 groupements de types de forêts differencient les surfaces boisées selon des fonctions principales exigées, c'est à dire la régime des eaux et la protection du sol. Pour les assurer il faut spécifier des mesures économiques à prendre. Dans cet article on en décrit la composition des peuplements selon des espéces, la durée de la révolution, la manière de la régénération, la technologie d'abbatage et du transport et le réseau des routes forestières. Toutes ces mesures ont pour but d'influencer activement le rôle des forêts sur le régime des eaux et la protection du sol parallelement avec la production du bois.

APPLIKATION DER ERKENNTNISSE UBER DIE MEHRZWECKIGE BEWIRTSCHAFTUNG DER WÄLDER MIT HYDROLOGISCHER UND BODENSCHUTZENDER FUNKTION

Mit der Entwicklung der Gesellschaft, die mit dem Anwachsen der Ansprüche auf die Naturquellen und mit der Industrialisierung der Landschaft verbunden ist, wird die einzweckige holzerzeugende Forstwirtschaft zum funktionel integrierten Wirtschaftszweig. Die früher willkürlich entstehenden, ausserökonomischen Wohlfahrtswirkungen des Waldes werden zu den aktiv getriebenen, nach dem konkreten öffentlichen Bedarf geformten Umweltfunktionen der Forstwirtschaft. Aktive Umweltfunktionen nimmt man als geplante Bestandteile der Forstlichen ökonomishen Tätigkeit auf.

Die Forschung vor allem in den letzten Dezenien hat eine Menge von wichtigen Erkenntnissen über den Einfluss der Waldbestände und ihrer Bewirtschaftung auf den Wasserkreislauf sowie auf den Bodenschutz gegen Wassererosion angehäuft. Aus der Analyse geht hervor, dass die hydrologische und bodenschützende Funktion wie durch biologische als auch durch biotechnische und technische Komponenten forstlicher Waldbewirtschaftung gestaltet wird. Es ist also nötig alle diesen Hinsichten im Komplex und planmässig im Rahmen der funktionell integrierten Forstwirtschaft zu respektieren.

Die Holzproduktion sowie die hydrologischen und bodenschützenden Funktionen sind vor allem von Naturbedingungen abhängig. Es ist notwendig, als Voraussetzung für mehrzweckige Ausnutzung der Wälder, die Aufteilung der Einzugsgebiete nach den Naturfaktoren durchzuführen. Zu diesem Zweck kann man die Waldtypen gut benutzen. Wir vereinigen sie von Standpunkten der bodenschützenden und wasserwirtschaftlich zweckdienlichen Einwirkungen in sg. wasserwirtschaftlich-bodenschützende Waldtypenkomplexe: Wasserschützender Komplex, 2. Infiltrationskomplex, 3. Bodenschützender Komplex, 4. Desuktionskomplex und 5. Niederschlagsbildender Komplex. Diese fünf Komplexe spezifischer Waldtypen gliedern die Waldflächen in wasserwirtschaftlich wichtigen Einzugsgebieten (Trinkwassertalsperren, Quellgebiete) nach den von der Wasserwirtschaft und vom Bodenschutz geforderten Haupteinwirkungen, zu denen Sicherstellung notwendig ist forstliche Wirtschaftsmassnahmen zu spezifizieren.

In vorgelegter Mitteilung beschreibt man folgende Wirtschaftshauptmassnahmen in mehrzweckiger Auffassung: Zusammensetzung der Waldbestände, Schlagperiode, Verjüngungsverfahren, Waldnutzungs- und Transporttechnologien, Wegenetz der Forstwirtschaft und forstliche Meliorationen (Entwässerung, Wildbachverbauung). Alle diesen Massnahmen und Objekte nehmen die Richtung auf die aktive, planmässige Beeinflussung der für den Bodenschutz und die Wasserwirtschaft wichtigen natürlichen und wirtschaftlichen Prozesse bei der Zusammenlegung der Holzproduktion und der Umweltdienste der Forstwirtschaft in den wasserwirtschaftlich wichtigen Wäldern.

LA APLICACION DE LAS INVESTIGACIONES ACERCA DE LOS BOSQUES DE USO MULTIPLE, ESPECIALMENTE DE FUNCIONES HIDROLOGICAS Y PEDOPROTECTIVAS

Con respecto al desarrollo de la sociedad y sus demandas a los recursos naturales, junto con la industrialización progresiva del paisaje, los bosques originalmente destinados a la producción de madera se transforman sucesivamente en los bosques de uso múltiple. El manejo de los bosques en los tiempos pasados fue enfocado a la producción, y las funciones sociales se cumplieron involuntariamente como funciones extraeconómicas de la silvicultura. Actualmente se exige, en conjunto con la producción de madera, asegurar activa y metódicamente las funciones ambientales, o sea sociales, según las necesidades locales como el componente de la actividad planificada; esto es económica.

En la gran parte del mundo se trata ante todo de aprovechar racionalmente las funciones hidrológicas y la capacidad de los bosques de proteger eficazmente el suelo (función contraerosiva) integrando dichas finalidades con la producción de madera en formas de manejo activo y consciente.

Las investigaciones amplias, sobre todo de los últimos dos-tres decénios, se han acumulado tanto los conocimientos acerca de la influencia de los bosques sobre circulación de agua en cuencas como acerca del mecanismo de protección contra la erosión pluvial. Al acomodar el sistema económico y de planificación (silvicultura integrada) y al conocer los factores bióticos, biotécnicos y técnicos cuales dominan dichos procesos, es posible planificar racional y metódicamente el manejo de los bosques con respecto al uso múltiple.

Como la producción de madera y además las funciones hidrológicas y contraerosivas dependen en el primer lugar de los factores naturales, hay que basar el propio manejo integrado en estos factores, como los syntéticamente expresan comunidades (o tipos) de bosques. La suposición del aprovechamiento de los bosques para el uso múltiple constituye en la división conforme del territorio de las cuencas según estos factores naturales. Con respecto a las funciones hidrológicas y pedoprotectivas pueden agruparse los radales (tipos específicos de bosques) según sus efectos predominantes y convenientes como sigue: 1. los bosques que protejen las aguas, 2. los bosques de infiltración, 3. los bosques contraerosivas, 4. los bosques de desucción, y 5. los bosques con la función de aumentar las precipitaciones netas. Estos grupos mencionados diferencian el área de bosques en cuencas importantes por la economía de agua (presas por abastecimiento de agua, zonas de las fuentes) según los efectos pretendentes, determinando así las propias formas del uso de los mismos.

En el estudio presentado se describen las medidas esenciales silvitécnicas y tecnológicas respectivas. Se trata sobre todo de las modificaciones de la composición de los rodales, de su estructura, de la moderación del edad de la cortabilidad o del turno, de los procedimientos de repoblación, de la tecnología de cortas y del transporte, de la construcción de la red de transporte de madera, etc. Las regulaciones recomendadas tienen que asegurar el cumplimiento optimal de la producción de madera junto con los servicios del ambiente.

Session IV

Costs/Benefits of Practicing Multiple Use

Estela Zamora, Moderator

Chairman, Man and the Biosphere Program, Philippines

Over the last few days, this conference has covered a spectrum of subject areas on multiple use of forest resources. Formal papers plus the sharing of research experiences among participants from 28 countries have provided a stimulating basis for interaction. The comparison of techniques for developing multiple-use information, the development of mathematical models for multiple-use planning, the application of multiple-use principles in forest resource management bring us through the hierarchy of field researchers, scientists, and planners and managers. And this afternoon, as we reached the crescendo of the final session, we faced the last and highest level: the policy- and decision-maker, whose decisions must be based on quantitative figures and who must say "yes" or "no" after studying the recommendations, weighing the alternatives and options, and considering the benefits derivable from certain costs in the only language that decision-makers appreciate, benefit/cost.

Today, we called upon that discipline, in whose field it falls to translate scientific research results, predictive models, and management recommendations into hard figures of dollars and cents: the forest economist. Our panel of speakers presented quantitative approaches to multiple-use planning, and discussed methods of monitoring during implementation. Considering that the emphasis on social values and human needs have grown in the recent years, research efforts have focused on non-commodity services such as recreation, in an effort to provide a common denominator for calculating benefits such as those obtained in wood production. It is interesting to note that apparent conflicts can be resolved by a careful analysis of supply and demand, as well as correction factors in the resulting increased costs of timber harvesting if the recreation component is superimposed on timber areas. The over-all consumer benefits can thus be derived after assigning values for non-commodity components to arrive at optimal levels of benefits for minimum costs, providing decision-makers with a clear-cut guide for decision-making as well as a methodology for monitoring during implementation of the multiple-use plans.

Bowes discussed capital budgeting on a land unit basis, with a cross-section of data from many sites over a short time, rather than a few studies of experimental sites over long periods. The theory and measurement of consumer benefits from multiple-use management covers three consumer sectors: 1) the timber sector, 2) quality-dependent commercial product sector (livestock, and 3) consumers with direct interest in stock quality (recreationists). Multiple-use supply is analyzed in a capital investment framework wherein the supply potential of individual land areas guides the manager in a sequence of decisions. Supply schedules summarize the optimal levels of output as a function of marginal values of each output, across product and across time.

Harou discussed methodology for monitoring to enable decision-makers to react to variances and reassess profitability of m ultiple-use plans. The Forestry Project Monitoring Cycle applies the principles of information feedback in cybernetic models: 1) pre-implementation appraisal, 2) optimum allocation of resources in time and space, 3) correction of periodical cash flow tables, 4) management decision givens, and 5) decision on the over-all project -- the alternative test.

Vesikallio discussed principles applied in the planning of recreational areas, environmental wishes of the users of recreational areas, observations on the users of forest recreational areas, and determination of the resulting additional costs in timber harvesting (10 - 50% increase). Recreational/excursion forests vs wood production forests present alternative multiple-use examples.

Recreation and non-commodity forest values must be included in multiple-use planning, according to Feuchter and Moeller. Assessing recreation benefits and equating input investement costs in output measures for multiple production costs is the subject of a planning process called the outdoor recreation opportunity resource inventory and management system adoped by the Forest Service. It identifies the mix of forest land management prescriptions that will yield optimum cost/benefits for both recreation and forest products. The recreation component must be quantified, outputs must be indexed to inputs, outputs should relate to human needs, and recreation output measures must be consistent with other measures of resource productivity and capability.

Multiple-Use Planning with Non-Commodity Services[1]

Michael D. Bowes[2]

Abstract.-- This paper provides an overview of the economic approach to decision making, a discussion of the demands for forest outputs, and a view of forest supply.

If I had been asked to briefly summarize my views on multiple-use management, I would say it is just another supply and demand problem. There is a point here. It is my feeling that there is a mystique of insurmountable difficulties to the multiple-use problem that is largely unjustified. What I want to do is present some selective thoughts on issues in evaluating supplies and demands for the various services of a forest area. It will be clear that the problem is not easy--the informational requirements guarantee against that--but nevertheless the economic logic of the management problem need not be conceptually difficult. My goal is to lay out a framework for thought and for future development of information rather than to give a detailed plan of action. I hope to make it apparent that there may be good possibilities for creative empirical work in evaluating demands for the non-commodity services of a forest area. On the supply side, I want to present a view of the forest manager as facing a typical investment problem. An analysis of the comparable problem for a firm in the private market provides a good degree of insight.

The structure of the paper is as follows. (1) An overview of the economic approach to decision making. (2) A discussion of the demands for the services of the forest. (3) A view of multiple-use supply.

MULTIPLE USE - AN ECONOMIC OR POLITICAL PROBLEM

It's probably fair to say that the present process of land allocation is significantly influenced by the relative strengths of the political voices of consumer groups. While recognizing that such a political role is inevitable and even desirable to some degree, such decision making should be understood in terms of its broader impact. I would like to point out first, the dependence of political pressures on the pricing policy of the public manager; and second, the tendency of such "conflict resolution" approaches to undercount the welfare of those parties who, as individuals, do not face large potential gains or losses but who, in aggregate, may bear great costs. Specifically, this latter group may include the general taxpayers and consumers or producers of goods which must compete for resources or markets with the National Forests.

Conflict Resolution Decision Making

Imagine the government managing the steel industry. I think it is fair to say that if the price of steel were set much below cost, the plant managers would find themselves facing great pressure to expand their capacity and produce more steel. They would no doubt try to expand their budget in order to meet what they perceive as an expressed public "need." Well, this is nonsense, of course. To produce extra steel requires resources. Labor, energy, and materials would have to be withdrawn from other potential uses. The unavoidable question has to be whether the public needs for steel dominate the needs for these alternative products. In responding to political noise the plant manager may neglect those who will face reduced supply and higher prices for the alternative outputs. Also, he is not likely to hear from the taxpayer who would bear the cost of expanding plant capacity. These groups are unlikely to be aware of the cause of their extra burden. I think it is hard to deny there are elements of this process in forest planning today.

Economic Decision Making

An economic approach to planning is not without faults, but I suspect many do not understand these faults in relation to its logical strengths. Its faults are those of any decision process. In the end you must compare someone's gain to another's loss and this comparison is inherently a political problem. This does not excuse the decision maker from an enumeration of costs and benefits.

With the possibility of offending those in the audience who have basic economic skills, let

[1]Paper presented at the IUFRO/MAB Conference on Multiple-Use of Forest Resources, Flagstaff, Arizona, May 18-23, 1980.

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me describe what is appealing about production at the intersection of supply and demand curves. An attraction is that at that level of production no shifting of the input resources between alternative uses could provide greater value to the public. The supply curve provides a measure of the cost of producing increments in our output. This cost is a reflection of the amount other producers would be willing to pay for the use of these resources. Thus it provides, indirectly, a measure of the value of these foregone alternative uses. The demand curve provides a measure of the worth of additional units of the product to the consumer. Any additional use of resources to produce beyond the point of intersection of supply and demand requires withdrawing resources from uses which are more highly valued. The resulting output will not be worth the alternatives foregone. Of course, even for non-market goods we may estimate schedules of resources costs in terms of value foregone and demand schedules in terms of value gained from incremental output.

Distributional Concerns

It seems undeniable that the public decision process should lead to a use of resources such that no reallocation among alternatives could increase public welfare. It is less clear that the measure of value expressed through the demand curve provides a suitable measure of welfare. It must be recognized that the measure of value expressed by demand curves is dependent upon individual wealth. For the individual, we can always find a monetary scaling of welfare based on dollar equivalents. However, we cannot generally make an unambiguous comparison of these dollar scales except under special assumptions. Who is to say that a dollar extra of consumption by one compensates society for a dollar loss by another?

A diagram may clarify the distributional issues. We will express the utility of an individual in terms of the wealth it would take for him to achieve a given level of satisfaction or utility. Let us assume more wealth is better but that extra increments of wealth provide decreasing increments of utility. The utility-wealth equivalence curve is represented in Figure 1 with U representing utility and Y representing wealth. There are two individuals, both with the same preferences. Individual A is initially at utility Ua°, which he views as equivalent to wealth level Ya°. Similarly, individual B is at Ub°, equivalent to Yb°. A project is available which would move A to utility level Ua' and move B to level Ub'. Comparing these changes we see that the increase in B's utility is less than A's loss and we might want to reject this project, especially since it tends to aggravate inequality. But what if the project were completed and B offered to pay A the amount Ya° - Ya' ? That compensation would result in A being no worse off than before while leaving B better off. B could have paid up to the amount Yb' - Yb° and still have been at an improved utility level. With compensation, the cost-benefit test comparing Yb' - Yb° to Ya° - Ya' is a perfectly suitable test of the acceptability of projects. Such compensation may be achieved indirectly through other projects or through taxes.

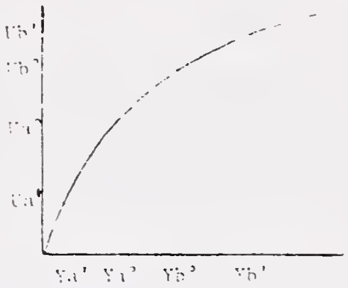

Figure 1

Now the cost-benefit criteria would accept this project on the basis of demand based willingness-to-pay even if compensation did not follow. This may seem less than reasonable, but suppose we said that society's preferences were such that we did indeed view the dollar loss to A as equivalent to the dollar gain. That is, we say that society accepts the resulting unequal distribution of income. Then, of course, there is no objection. Alternatively, let us say that society views each individual with equal concern. In this case we may want to weight income changes to A more heavily than to B. In particular we could weight each individual's benefits by their marginal value of a dollar. That is, to A on average, a dollar will be worth Va=(Ua°-Ua')/(Ya°-Ya') and to B a dollar will be worth Vb=(Ub'-Ub°)/(Yb'-Yb°). Then a weighted cost-benefit test comparing Va(Ya°-Ya') to Vb(Yb'-Yb°) reduces to a direct comparison of the utility changes. With these distributional weights the project is rejected.

These weights are a social or political issue, hardly in the realm of the local analyst. And, always the cost and benefits must be evaluated. It should be clear that making decisions purely to resolve political noise does not avoid the broad economic implications of a decision. With sufficient skill and information, an economist could derive the relative weights that are implicit in such choices. I wonder if those implicit weights would be pleasantly received by the public.

Discounting

Related to the distributional concern is the matter of discounting. Discounting should be understood as a means of reflecting the opportunity costs of foregone alternative investments. Look at a project which yields B dollars one year after an investment of C dollars. The discounted net value criterion would accept this project if B/(1+r)-C>0. Now consider an undiscounted cost-benefit test which accounts for opportunity costs. In particular, we could have lent out C dollars at the market rate and received (1+r)C dollars next year. We will choose our project only if it is better than this alternative opportunity: or if B-C>(1+r)C-C. This is seen to be identical to the discounted cost-benefit test.

To further reflect intergenerational equity considerations we could attach additional weighting

to benefits and costs over time. A lower discount rate--below that reflecting opportunity costs--may be viewed as penalizing the present in favor of future generations.

Local Income

It is the nature of unweighted cost-benefit analysis that we are willing to accept a loss to one community as long as it is offset by a gain elsewhere. Typically, it is assumed that declining income and employment in one region will be offset by a shift in resources and income to other regions or sectors of the economy. However, the approach need not ignore underemployment that results from friction in this shifting of employment patterns. Recall that supply cost should be a reflection of social opportunity cost. The social opportunity cost of using otherwise underemployed labor may be considered to be the value of this labor in the best alternative use. Effectively, this allows us to consider the extra income earned by factors (above their best alternative income) as a project benefit (or a subtraction from costs). The planner should be careful in not overstating these income effects. There is a flexibility in the economy that input-output models projecting employment often fail to capture. Further, it should be recognized that wise choice of policy may ease employment transitions and that more efficient means of income subsidy may be available.

Comments

It is my feeling that the nature of the forest outputs is such that little basis exists for removing the allocation process from an economic framework. Economic criteria may be of limited interest in certain public decisions such as those affecting public health and safety. For such concerns the social issues of equity and interpersonal tradeoffs so dominate that measurement of benefits and costs is a relatively trivial point. The outputs of the forest would not seem to be in that class. Many are typical consumption goods; many compete with private market substitutes. Good economic management should adequately deal with immediate environmental and commercial concerns and also provide well for the future.

AN OVERVIEW OF MULTIPLE-USE MANAGEMENT

I am going to consider the management possibilities for a sub-area of a forest in very general terms. This area should be viewed as competing with other lands to meet public demands for its services. The location, resource qualities, facilities, access and stocking conditions of this unit will be weighed by consumers against the advantages of other land areas. The manager can respond to these demands and choose a pattern of land use and treatments that will best meet the public needs. This chosen pattern of use may or may not be single purpose depending on the relative strength of demands. I think it is most interesting to consider the area to be one which is not obviously to be used for one particular purpose. The land need not be considered timber land.

The view I take is of the land manager making a sequence of land treatments over time with the result a flow of harvests (if applicable) and an evolving condition of the land. This condition will be represented by a vector of quality outputs. By this I mean descriptive measures of the land condition that may be found to be determinants of consumers' valuation of the area. For example, they may be indices of stock diversity, edge, scenic quality, crown cover, clearings, accessibility, or facilities. Treatments may be a very general set of possibilities for vegetation manipulation, development of facilities, restrictions on access, or other actions which may promote the value of the land for one or several uses.

The stress on forest condition as the link between supply and demand has some advantages. What is sought is an unambiguous separation of supply from demand and a reduction in dimensionality. Reducing the description of forest area to a set of indices of qualities is essential if one is to manageably relate consumer value to the forest condition. Effective multiple use management will call for increased understanding of the ability of the manager to manipulate the quality outputs and of course for improved understanding of consumer interest in the quality of forest resource condition. The point I wish to stress is that management is to serve the public and the focus in study must be on the identification and control of those factors which can be shown to influence consumer demands. It is on the demand side that research has been especially negligent.

Typically, the service quality outputs will only be meaningfully defined over a significant area of the forest. That is, consumers are likely to view the interrelations of conditions over several individual stands in forming their evaluation. We will only be able to reflect multiple-use values properly by considering these functionally related areas as a whole. So contrary to typical practice, the sub-area considered here may be thought of as quite large and be non-homogenous in land and stocking condition.

An Introductory View of Multiple-Use Demand

Let us take there to be a set of estimated consumer benefit functions. The benefit functions will depend on the level of service qualities of our land area relative to alternative sites. For timber purchasers the benefit function will depend on the quality and accessibility of harvest sales at each site. The benefit or value function for each group of consumers will be represented by $B^i_t=B^i_t(P_t,X^i_t,Q_t)$, where P is a vector of various market prices; X^i is the vector of stumpage supplied to party i from each of J sites; and Q is a vector of qualities at these sites. The index t refers to time.

These benefits will be defined, for convenience to include any amount actually paid to the forest. In a later section we will consider how such bene-

fit functions may be evaluated and discuss those relevant for inclusion in a study.

An Introductory View of Multiple Use Supply

The manager of the forest sub-area has a number of allowable treatments which can be instituted at each point in time. The specific sequence of management actions and practices will result in supplies of harvests and service qualities over time along with corresponding input needs. Each such supply sequence will be referred to as a production possibility. There will be many, each associated with particular combinations of treatments over the unit's stands and over time. Among the production possibilities are a set which we shall call "cost efficient." These are supply streams such that no other set of treatments could lead to more of one output while providing at least as much of all the others except by increased cost. The set of these cost efficient supply paths is called the production possibility frontier. It could be called the multi-time-period production frontier to stress the concern for future supplies.

A convenient way to represent the frontier is in terms of the cost of producing a given supply stream. More specifically, a site's cost function will be defined as giving the least discounted cost required to produce a particular stream of harvests and qualities. This is represented as:

$C_j = C_j(x_j, q_j, w, r)$ where x_j is a vector of harvest supplies for time periods up to time T from site j; q_j is a vector of N quality outputs for time periods up to time T. These least cost solution values will depend on the given output schedules, on input prices w, and on the discount rate r. We can conceive of the expression as summarizing the solutions to a mathematical programming model of the forest area.

The Planning Problem

The overall planning problem for the unit is to maximize the following problem by choice of a supply schedule for site j.

$$(1) \quad L_j = \sum_t \sum_i B_t^i/(1+r)^t - C_j$$

We consider the management of our one site as if the other site supply levels and prices are determined. The solution is to choose outputs at a time t so that: (a) the marginal discounted benefit to any timber purchaser is equal to marginal discounted cost, (b) the <u>sum</u> of marginal discounted benefit to all groups valuing a resource quality should equal the marginal discounted cost of producing that quality.

A rather careful interpretation of marginal cost is required for these dynamic problems. It should be taken to mean the cost of an increment in one output while adjusting practices to ensure that all other outputs are held constant--including future harvests and qualities.

Typically we are not used to thinking of continuous possibilities for adjustment of forest outputs, so let us look at the analog under discrete adjustments. For simplicity consider just one output and two time points. Obviously, if we can find an alternative which increases net benefits we could not have been at the optimum initially. Consider an initial supply sequence (Y1,Y2). A move to an alternative supply sequence (Z1,Z2) is preferred only if the increment in benefit exceeds the increment in costs. On comparing the net benefits from both supply sequences and rearranging terms, we find the alternative preferred if

$$(2) \quad B(Z1)-B(Y1) > [C(Z1,Z2)-C(Y1,Y2)] + [B(Y2)-B(Z2)]/(1+r).$$

Suppose that we wish to increase timber harvest today by switching to an alternative set of practices. Then the gain in present timber benefits must outweigh the change in total discounted monetary costs plus the opportunity cost of foregone outputs in the future. Similarly with many outputs, any present increase in one output should have benefits outweighing the change in money cost plus foregone benefits of present and future outputs. Any production beyond this point would imply that resources had been withdrawn from more valuable alternatives. Expression (2) is analogous to saying we should increase one output only if the marginal benefits exceed marginal cost. Note that land is "submarginal" for present timber harvests if no alternative including such harvests passes the test (2) when compared to the best no-present-harvest alternative. This is the only meaningful test for sub-marginality; other attempts to allocate costs to specific outputs are meaningless and likely to lead to misallocation. The joint nature of forest production cannot be avoided.

BENEFITS FROM MULTIPLE USES

In this section we will consider some issues in the theory and measurement of consumer benefits from multiple-use management. The focus is on benefits appropriate for inclusion and on the revelation of values through observable data. We would like to measure the impact of changes in the forest unit production in terms of the welfare impact on all affected parties. These parties will include direct users of the forest output. In addition, the outputs of these direct users may pass through further levels of processing and ultimately be converted to final consumer products. These latter firms and consumers will be affected through price impacts. In the following discussion some general tools for the measurement of welfare changes are presented. This is followed by a discussion of simplified measurements for three consumer sectors: (a) the timber sector; (b) the quality dependent commercial product sector (e.g., livestock): and (c) the consumers with direct interest in stock quality (e.g., recreationists). It can be shown that when secondary processing and supply markets are competitive then the observable behavior of parties dealing directly with the forest will reflect the welfare of the full sector.

Methods

Some general tools for monetary measurement of

benefits are presented here. They may be viewed as constructs designed to ensure that the maximization of problem (1) will lead to competitive type allocations.

Firms

The benefits to firms processing forest based outputs will be represented by profits plus payments to the forest unit. The aggregate benefit to firms in the sector will be represented by a function which depends on final product price P, on market input prices R, and on either X or Q (depending on the nature of the products). So the sum of individual firm benefit functions can be represented by either $\pi(P,R,X)$ or $\pi(P,R,Q)$.

Consumers

For consumers we can define monetary welfare measures in the following manner. The expenditure function gives the least income needed to attain a given utility U when market prices are R, prices influenced by forest production are P, and site qualities are Q. Represent the sum of individual expenditure functions by $E(P,R,Q,U)$.

For consumers of forest resource qualities, monetary benefits including payments to the forest can be represented by $CS(Q,R,U)=E(Q'',R,U)-E(Q,R,U)$ where Q'' is a base level of service and Q is any planned level of service. For consumers of final products, rather than forest outputs, we will be interested in the impact through final good prices. We would like a measure of the extra income which would just make up for the impact of any prices change resulting from site output. The sum of these measures over individuals can be expressed as $CS(P,R,U)=E(P'',R,U)-E(P,R,U)$ where P'' is the price vector for goods when there is no site production and P is the price under some planned level of output. These expressions can be viewed as consumer surplus measures of value.

Technical Properties

Certain properties of the functions π, E, and CS make them especially useful. In order to simplify our procedures for measuring benefits, we will rely on the following.

For the firms' profit function: (a) the derivative with respect to a change in quality at site j gives the aggregate demand price (over firms) for site quality, $\sum_i V_j^i(P,R,Q)$; (b) the derivative with respect to x_j^i, the harvest supply to firm i from site j, gives the individual demand price for such harvest, $S_j^i(P,R,X)$; (c) the derivative with respect to an output price gives the aggregate supply function, $Y(P,R,X)$; and (d) the derivative with respect to an input price is the corresponding input demand function, $Z(P,R,X)$.

For the expenditure function: (a) the derivative with respect to a quality change at j is minus the aggregate consumer demand price for the quality output, $\sum_m V_j^m(P,R,Q,U)$; and (b) the derivative with respect to price is the aggregate demand for the associated output, $D(P,R,Q,U)$.[3] So for the consumer surplus functions: (a) the derivative with respect to price is minus the aggregate demand for the output; and (b) the derivative with respect to quality is the demand price for quality.

Benefits in the Timber Sector

Full sectoral benefits are given by the sum of consumer surplus to final consumers plus profits to producers plus payments to the forest. We wish to be able to evaluate the change in these total benefits due to changes in production at a particular site (label it site 1). This can be measured using the processing firms' input demands for stumpage. The approach presented here is not the typical approach which calls for measuring profit changes in directly affected firms and assuming that secondary impacts are negligible or at least off-setting.

Total sectoral benefits are given by

(3) $B(X,R)=CS(P^e,R,U)+\pi(P^e,R,X)$, where

$P^e=P^e(X,R,U)$ is a vector of equilibrium prices for final goods. These prices will be those consistent with aggregate supply equal to aggregate demand. We will be interested in the marginal benefits. Using the technical properties of the benefit functions and the market equilibrium conditions it can be easily shown[4] that

(4) $\delta B/\delta x_1^i=\delta\pi_i/\delta x_1^i=S_1^i(P^e,R,X^i)$ where

π_i is the individual benefit function for firm i. So the marginal value we need is reflected in the demand behavior of the stumpage purchasing firm.

The benefits attributable to site 1 timber production over one time period may be measured by the sum of areas under stumpage demand curves up to the level of actual supply to the firm. That is

(5) $B(X,R)-B(X',R) = \sum_i \int_0^{x_1^i} S\ (P^e,R,X^i)dx_1^i$

where $X = (X_1,X_2,\ldots,X_J)$ and $X' = (0,X_2,\ldots,X_J)$.

So for each firm we should measure the shaded area illustrated in Figure 2 (below).

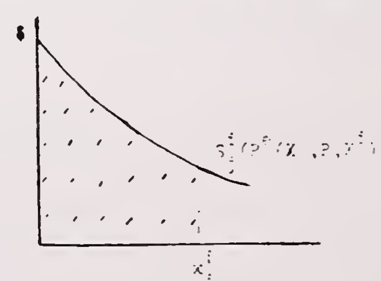

Figure 2: Timber Benefits

Expression (5) should be used as the measure of timber sector benefits in problem (1). It will lead to the identical allocation as if we had used

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[3] The "compensated" or constant utility demand. We will consider utility constant at the level associated with supply demand equilibrium.

[4] Notice that $(\delta CS/\delta P^e)(\delta P^e/\delta x_j^i)+(\delta\pi/\delta P^e)(\delta P^e/\delta x_j^i)=$

$(-D+Y)\delta P^e/\delta x_j^i=0.$

the full sectoral benefits given by expression (3).

Quality Dependent Commercial Sector

The full sectoral benefits could be measured by

(6) $B(Q,R) = CS(P^e,R,U)+\pi(P^e,R,Q)$

measured for the appropriate consumers and firms. Using argument identical to that in the previous section we can show that marginal sectoral benefits due to site 1 quality changes can be found as $\delta B/\delta q_1 = \delta\pi/\delta q_1 = \sum_i V_1^i(P^e,R,Q)$. The public good nature of the resources qualities should be apparent. The marginal effect on sector benefits is to be evaluated by the sum of demand prices of all individual firms.

We could then express the sector benefits attributable to our site by a sum of areas under the quality demand curves. That is, by

(7) $B(Q,R)-B(Q',R) = \sum_i \int_{q_1'}^{q_1} V_1^i(Q,P\ ,R)dq$,

where $Q=(q_1,q_2,\ldots,q_J)$ and $Q'=(q_1',q_2,\ldots,q_J)$ with q_1' a vector of base level quality supply. Unfortunately, the demand for quality may not be directly observable. Consider this alternative approach. (See Mäler, 1974, and Freeman, 1980, for related discussion). It may be easily shown that

$$B(Q,R)-B(Q',R) = \sum_i \int_{q_1'}^{q_1} V_1^i(P^e(R',Q),R',Q)dq_1 +$$

$$(8)\quad \sum_i \int_R^{R'} Z_i^*(P^e(R,Q'),R,Q')dR -$$

$$\sum_i \int_R^{R'} Z_i^*(P^e(R,Q),R,Q)dR.$$

While looking forbidding, this result proves a real convenience. By choosing an input price R' so that the first term on the right is zero, then we can measure our benefits using knowledge of the input demand functions. For example, consider R' to represent the price at which an essential input is so expensive that use of the service of site 1 would stop. Perhaps this could be travel inputs for firms which have to physically get to the site. Alternatively, consider R' to be a sufficiently low price for a substitute input so that at that price the substitute would replace site use. This may be other facilities providing the same type of service. The resulting evaluation procedures are illustrated in Figure 3a and Figure 3b (below).

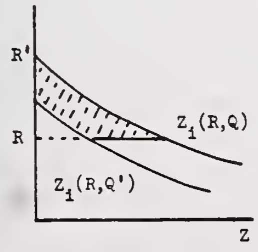

Figure 3a: Complementary Input Method

The measure of benefits is the area between actual input price R and a price R' at which site quality value to the firm is zero. The two demand curves reflect the shift in input demand resulting from alternative site quality levels.

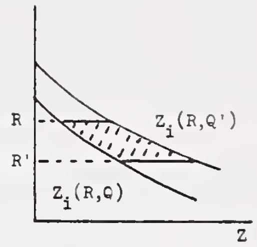

Figure 3b: Substitute Input Method

Higher site quality increases the demand for complementary inputs and decreases demand for substitutes.

Consumers with Direct Concern for Forest Quality

It is the evaluation of these groups that has typically been ignored. However, their benefits need not be difficult to measure. The total benefits to these consumers, including any fees paid, is given by $B(Q)=CS(Q,R,U)$. The marginal benefits to the group can be expressed as $\delta B/\delta q_1 = \delta CS/\delta q_1 = \sum_m V_1^m(Q,R,U)$. Again we can see the public good nature of quality outputs. The marginal value of quality to these consumers is the sum of individual demand prices.

The incremental benefit to the group can be expressed as

(9) $B(Q)-B(Q') = \sum_m \int_{q_1'}^{q_1} V_1^m(Q,R,U)dq$

and this could be used in problem (1). Again, though, the right hand side is unlikely to be directly measurable since it requires knowledge of the demand for quality. As in the previous section it may be indirectly measurable through the consumer demands for related market goods. The description related to Figures 3a and 3b is exactly applicable here.

The obvious example of evaluation by such techniques is the well known travel cost method for evaluating recreation demand. In Figure 3a let R' be the travel cost at which site use would stop. Let R be the actual travel cost. Then an accurate measure of benefits from site quality changes is found by considering the shift in travel demand due to the change in site quality. That is, we should measure the shaded area in Figure 3a between the two demand curves and between prices R and R'.

Comments on Multiple Use Demands

I would like to make some summary points related to valuing commodity services. First, the use of constant unit shadow prices on a national or regional level may be quite inadequate. Second, the pricing decision should be recognized as separate from the allocation decision under the cost-benefit assumptions.

It is apparent that National Forests are planned with at best an intuitive idea of the economic value of increments in quality services. There has recently been some move to national or regional sha-

dow prices for final services such as number of recreation visits. These will be of little use in planning since management typically alters the quality of site use experiences more so than the number of experiences. A day of recreation is not equally valued everywhere. Most demands for quality services are local in nature, dependent on the distribution of population around a forest and on the accessibility of particular sites relative to substitutes. Constant unit prices are likely to lead to overexpenditure on the less accessible forest areas.

Pricing of outputs is a distributional matter. The allocation we have discussed does not require that price be set at marginal value. However, the advantage of such pricing should be clear. First, it seems fair that people should pay for services provided. Second, prices serve as a rationing mechanism resolving economic conflict. Prices consistent with the efficient allocation are those which ensure that no individual would want the allocation changed. However, the nature of the quality outputs makes such pricing difficult. The appropriate prices for each group of quality users may differ. Further, access can be hard to control. In some cases collection of fees may be unreasonably expensive. Pricing of quality services may always be based as much on practicality as on principle. Nevertheless, the efficient allocation remains[5] and the manager should find a rationing scheme to ensure that units are managed with incremental value at least equal to incremental costs.

MULTIPLE-USE SUPPLY

Up till now, I have provided a largely demand based view of multiple use. Even in a perfectly homogenous forest, each unit with the same supply potential, demand conditions may lead to a varying mix of practices throughout the forest. Relative demand prices for service and outputs will differ with the accessibility and visibility of units from the centers of population and we should expect varying degrees of specialization or combined production depending on these marginal values. The allocation principle is that a dollar allocated to any one site should produce an equal return to the public. This may be accomplished by adjusting either the mix of outputs on sites or the spatial distribution of expenditure over sites. If the rule is not followed, some reallocation could always lead to greater public welfare.

Let us now look at the characterization of supply potential of individual land areas. That is, at the cost-efficient supply schedules. First, I express the planning problem in a typical capital investment form.

Capital Investment Framework

For the analysis of multiple-use supply, it is convenient to assume the following framework. Consider one sub-area of the forest made up of several stands of vegetation. The land manager is faced with a sequence of decisions over time. At each such point in time he observes the stocking condition of stands within the area and then chooses among a number of alternative land treatments one to be instituted until the next decision time. In making these choices, he must consider the resulting harvests, costs, quality flows, and the change in land condition. The quality flows are likely to depend on the interrelation of stocking conditions and the chosen actions across all stands. The result of a sequence of such decisions is a time stream of costs, harvests, and a set of stock quality outputs. In addition, the land condition will be altered. So we consider the manager choosing among a number of short term "activities," one to be instituted for the next, say, five years. These activities fully describe the use of the land area.

Consider how decisions are made in private markets when output prices are known. For example, consider how units of the forest would be used if quality services were saleable and there were an active market in land transfers. In making the decisions as to whether to buy a land unit, the potential buyer considers the full range of possible activities and would offer to purchase the land if the best such activity led to an expected return greater than or equal to that available from alternative uses of his funds. Considering the alternative to be investing at a market rate r, he would buy land for this period if discounted benefits of the best activity exceeded costs. In evaluating benefits and cost, the purchase and potential sale price of the land would be considered as costs and benefits respectively. The change in land value is a capital gain. So, land will be bought and used in activity j* only if

$$\max_j \, [V(j,t+1)+R(j,t+1)-(1+r)(V(t)+C(j,t))] =$$

$$[V(j^*,t+1)-V(t)]+[R(j^*,t+1)-(1+r)C(j^*,t)] - [rV(t)] \geq 0, \tag{10}$$

where V is the land value, R is revenue, and C is operating cost. The index t is a time index and j is an index of the activity. The revenue, costs and subsequent land value will depend on the chosen activity. Revenue is presented as if paid at the end of the period while costs are as if incurred to begin the period. Land will be put into activity j* only if the capital gain plus net operating revenue exceeds the opportunity cost of the initial investment in land. In fact, competition in the purchase of land will ensure that expression (10) will hold as an equality. Potential buyers bidding for the use of the land will drive the present land price to the level at which the most profitable activity will just make the going rate of return; any other activity would lead to a lower return.

In a free market the investment decision may be made based on market revealed output and capital prices. The manager of the public lands is not so fortunate; he must estimate the marginal value of

[5] At least that is true if pricing does not introduce serious distributional concerns.

outputs and he must estimate the value of his stock of land by forecasting the value of future streams of outputs. Nevertheless, the supply rule (10) still describes the allocatively efficient path of management. The manager, of course, should act as if the marginal value of all outputs were received even if actual prices differ.

We may note some implications of the management rule: (1) In any given period it may be quite acceptable to face losses (evaluated at shadow prices) in the current operating account as long as the capital value is increasing sufficiently to offset both these losses and the opportunity cost of the land value. (2) We will not generally select that activity with the highest immediate payoff since this may be offset by a decline in land value. (3) If there were no service values and activities were either to cut or let grow individual stands, then the rule would correspond exactly to the Faustman type harvesting solution. In general, rotation ages may differ significantly from Faustman ages. In fact, because of the interdependence of stands in determining unit quality services, no simple rotation age emerges, even under assumed constant prices over time.

Multiple-Use Supply

Suppose that we have enumerated the potential set of activities. How can we represent supply potential? Typically we do not know the output prices (or marginal valuations), except approximately. Let us imagine solving the problem of finding optimal supplies for a particular set of reasonable prices and doing so many times for varying combinations of prices. We will then have found the supply schedules for present output. That is, we could plot the optimal levels of a present output against its own price and prices of other present and future outputs. Typically we will find that present supply is influenced by these other prices. That is, the products are "joint."

Obviously we would expect increased present supply of one output should be forthcoming in response to a higher own price in the same period. A higher own price for future timber harvests would generally call for reduced present supply as we attempt to build up stocks. More interesting is the link across products. Would a higher demand price for a quality service tend to reduce the optimal supply of timber (substitutes in supply) or increase the optimal supply of timber (complements in supply)? Either is possible. (This linkage implies nothing about whether the outputs should be produced on the same unit: that will depend on the final relative marginal values).

While it would not be necessary to evaluate the supply curves in order to solve the planning problem, they do serve a convenient summary purpose. It can be very hard to comprehend the information embodied in a large set of activity coefficients. Much forest planning literature has made the mistake of relying on anecdotal descriptions of the effects of individual treatments as if that meaningfully described product linkages. Such descriptions are misleading. The relevant concern is the direction of adjustment in each output level that should follow from a change in marginal value of another output. This optimal adjustment will come about through a complex mix of treatments and a focus on any one treatment is deceptive at best.

Supply schedules conveniently summarize the optimal levels of output as function of marginal values of each output, across products and across time. Their presentation in some practical form should make it clear to the political decision maker that any allocation decision comes down to the implicit choice of shadow prices for outputs. An intelligent debate over these prices based on a combination of empirical evidence and political judgement would be a step in the right direction.

SUMMARY COMMENTS

Research needs are clear. If management is to serve the public then we must quickly begin to discover those elements of forest condition which the public values, estimate the extent to which they are valued, and study the costs of manipulating these service qualities. We can go nowhere until the forest begins to track individual units on a capital budgeting basis. For sample units we must know inventory conditions, the sequence of treatments, the associated sequence of costs and outputs (or use), and the resulting change in stock inventory including changes in the quality indices over some period of years.

A cross-section of data from many sites over a short time period is of more immediate use than a few studies of experimental sites over long horizons.

I would also suggest a study of private land sales to see if such land values would provide some help in applying the multiple-use decision rule given by expression (10). Finally, I would suggest the intuition behind expression (10) be carefully learned. There is no easier rule of thumb for multiple-use planning. You may notice that another form of this rule was given earlier by expression (2). Any attempt to plan for individual outputs by allocating costs in a manner not consistent with these optimality conditions is sure to lead to error given the inherent jointness of production. The move towards budgeting by single outputs is misguided and is delaying the preferred move to capital budgeting on a land unit basis.

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EL PLANEAMIENTO PARA USO MULTIPLE CON SERVICIOUS ESTETICOS

El tema de la presentación es sobre un metodo economico en administración de bosques, incluye comentarios sobre la demanda de buen despachos de los bosques. El papel también presenta una vista sobre producion de bosques.

PLANS D'USAGE MULTIPLE AVEC DES SERVICES PUBLICS

Nous presentons un cadre économique pour la gestion des forêts, quelques remarques sur les methodes pour la quantification des demandes des biens et services des forêts, et un vue de la production des forêts, le dernier dans un cadre de la théorie des investissements.

VIELFALTIGE NUTZUNGSPLANUNG OHNE GEBRAUCHSGUTERLIEFERUNG

Diese Studie beinhaltet eine ökonomische Betrachtungsweise der Forstwirtschaft, eine Untersuchung der Methoden zur Messung der Nachfrage nach forstwirtschaftlichen Gütern und Dienstleistungen, sowie eine Behandlung des forstwirtschaftlichen Angebots unter besonderer Betonung eines Kapitalbudgetrahmens.

Monitoring the Performance of Multiple-Use Forestry Projects[1]

Patrice Harou[2]

Abstract.--Since the management of multiple use forestry projects is a dynamic process, projects are seldom implemented exactly as they appear in the initial appraisal or project plan. Thus, with changes in a project being the rule rather than the exception, it becomes important that a careful monitoring methodology be set in place at an early stage in the life of the project. Periodic comparision of estimated and actual costs and revenue figures should permit the decision maker to react quickly to unexpected variances. The alternative test should be used to reassess the profitability of the project, in whole or in part, during its implementation.

INTRODUCTION

Forestry projects will usually produce more than one output. In developed countries, typical multiple use of forest land will include products such as timber, recreation, water yield and quality, grazing, wildlife, amenity. In developing countries, agro-forestry project (taungya) is the most common multiple use project.

Investment in any forestry project is rarely made without an appraisal that predicts its profitability (Cost-Benefit Analysis). Non public projects are evaluated from the individual investor's standpoint (Financial Analysis). Public projects however are looked at from the standpoint of society (Economic Analysis). The Economic Analysis exludes transfer payments and uses shadow prices when market prices are not relevant. Both types of analyses, the economic and the financial analysis, are undertaken to decide to invest or not in a particular project alternatives. When this is done, and the decision has been reached to invest in the project, then begins the most important step in project management: carrying out the actual implementation of the project. The appraisal of a multiple use project is relatively straight forward compared to the task of managing it.

This paper proposes a conceptual framework to monitor and control multiple use forestry projects, once the decision has been made to invest in a particular project.

The objectives of the model framework are to develop a conceptually sound approach to reducing the impact of unforeseen events on the project outcome and to develop a thorough understanding of the nature of risk and uncertainty in multiple use projects.

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Frequently a crucial step in the project planning process is omitted - setting up a procedure to monitor progress toward the financial or other goals set by the appraisal. This monitoring of a project is particularly important to set in place for public types of projects and projects for which non timber production is the principal output (recreation, watershed), because these projects lack the inherent feedback (dollar profit) encountered in the private sector.

The methodology to monitor the performance of a multiple use project could be the same for the public or the private sector provided that cost-benefit analysis is used to both appraise and monitor project performance. This is the case that will be discussed here. It is assumed that maximization of Net Present Worth (NPW) is the criterion to maximize given the relevant environmental and political constraints. This is the relevant criterion for both financial and economic project analysis. Although this phase of project planning (monitoring) is recognized as essential in formal discussions (Marquis, 1970) it tends to be ignored in practice.

A. Lundgren, 1976, argues that: 1) this crucial step is omitted in part because we usually plan it out as though the future were known with certainty. 2) in fact the future brings unexpected changes, 3) our actions inevitably produce unexpected consequences which cannot be fully anticipated, and 4) we can and must plan for the unexpected.

THE MODEL FRAMEWORK

The conceptual framework is summarized in the model of figure 1. The model called the Forestry project monitoring cycle (FPMC) has been described in details by Harou, 1978.

The FPMC is based on the application of the principle of information feedback in cybernetic models (Beer, 1967). The thermostat is the typical example given to explain the homeostatic character

of such models. The FPMC distinguishes 4 different feedbacks and a continuity of direction flows. The model presented in figure 1 is essentially composed of 5 different interdependent blocks considering successively 1)the preimplementation appraisal 2) the optimum allocation of resources in time and space 3) the correction of the periodical cash flow table of the ongoing project 4) Management decisions given 3), 5) and finally a decision on the overall project: the alternative test.

PREIMPLEMENTATION APPRAISAL

Once the need for a product or a mix of product has been established by a detailed market analysis, and public participation, different alternatives are proposed to fulfill this need. Some alternatives are retained for future analysis. Eventually some private or public sponsors will decide to invest in what they consider to be the "best" project to achieve some set of goals.

The analysis on which such a decision is based is crucial. Input-output relationships for the life of the project are estimated and converted to monetary terms using market prices in the financial analysis and shadow prices in the economic analysis. But the figures obtained are only best approximations. Uncertainty about the figures exists at two levels, the input-output estimates and the price estimates. Both are affected by controllable and uncontrollable variables. For example, climatic variation is uncontrollable and difficult to forecast accurately. On the other hand the quantity of fertilizer used in a plantation is under the control of the manager.

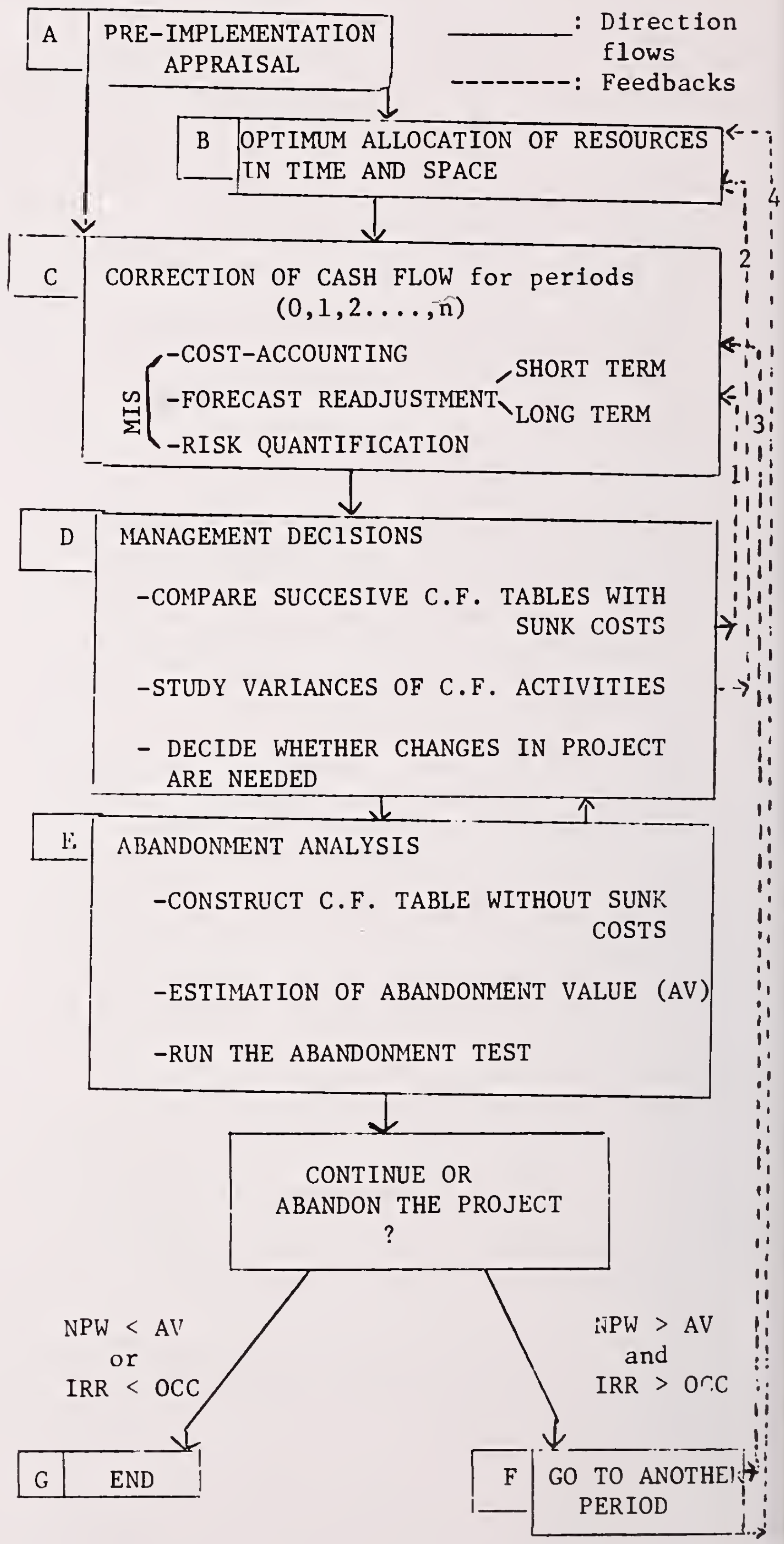
The preimplementation appraisal very often includes average figures for simplicity and to reduce the cost of the appraisal. However use of averages is particularly misleading in forestry projects because of long time horizons and, great variability in site, climate, species, and management possibilities. Even so, the preimplementation appraisal is used as the standard against which project progress will be monitored. The precision of the preimplementation appraisal is thus crucial. Comparison of the actual performance of a project with an improperly set standard would be meaningless. The trade-off between the precision and the cost of the appraisal has to be considered carefully. High precision in the initial appraisal may pay off quickly during implementation.

OPTIMUM ALLOCATION OF RESOURCES IN TIME AND SPACE

The precise allocation of resources to a forestry project should be considered in the preimplementation appraisal. But if this is not done it then becomes the first task for the project manager in charge of the implementation of the project to allocate his or her initial resources (capital, land, etc.) as wisely as

FIGURE I

The Forestry Project Monitoring Cycle (FPMC)



possible.

Once a firm is committed to a project output goal, the criterion used to assess a management decision will be cost minimization (if benefits cannot be assessed for some benefits) or, better, maximum net benefits. Both of these criteria are subject to constraints not only those prior to the appraisal but also the ones raised by the appraisal itself. The appraisal includes a certain amount of working capital, number of workers... that are fixed at least in the short run. Operational research techniques such as linear programming and network analysis are helpful in resolving these problems of constrained maximization encountered in implementing a project. Those models require knowledge on the input and output of the principal activities of the project. The coefficients quantifying those input-ouput relationships will have to be provided for each management unit and be monitored during the project. The price of those inputs and outputs should be monitored also. A management unit consists in a part of a project, having a particular stream of cost and/or revenues, that has to be discerned for correct implementation. As will be explained in a moment, an economic site index class could be considered as one management unit.

The information required to update the allocation models is provided through feedbacks 2 and 4 (see figure 1). Feedback 4 consists in updating the coefficients and price figures included in the model after each period. Feedback 2 corrects the model subsequently to a decision to change some part of the project (e.g. the recreation output), to change the forecasts (input, output or price forecast) or to change some component or the whole allocation model.

The first and most important task in the implementation of most multiple use projects is to allocate the given inputs optimally among different final outputs and among different economic site classes. Economic site index refers to the physical and economic characteristics of a particular site which distinguishes it from other sites. By allocating funds optimally to the most profitable uses and productive areas, the earliest net benefits become relatively more important and the less advantageous investments are postponed. This improves the overall profitability and reduces the risks of the investment. Usually there exist several different economic site index classes in a single forestry project. The use of parametric linear programming (L.P.) is useful to rank investments on the different site classes of a forestry project. The use of such L.P. techniques for this purpose has many precedents (Buongiorno, 1973; Murphy, 1976) (2.7). LP will also be very useful to schedule harvesting.

Successful implementation of a project depends upon precise timing of many critical inputs. Plantation activities, for example, require the mobilization of most of the resources available from a forestry project during a very short period of time. To avoid problems during implementation, it is recommended to specify how the inputs are to be organized and scheduled and how they will interact during the life of the project. The special technique used in management science for coordinating work assignments and resource utilization with project objectives is called network analysis or critical path method (CPM) or Project Evaluation and Review Technique (PERT). PERT effectively contributes to two critical features of project planning: formulating the initial plan and monitoring its progress. PERT can be used to monitor the physical input-output of the project and the cost of the project as well (PERTCOST). PertCost can be used in the updating of the project cash flow in block C.

Other operational research allocation models can be used to foster increased orderliness and consistency in planning and evaluation within all stages of the project implementation. Simulation, other mathematical programming model, Markov chains and queuing are all techniques that can help allocate the resources devoted to a project.

Flick 1975, uses Input-Output analysis to value non-market goods in multiple use management. The prices obtained reflect public decisions. When these decisions change, the model need to be rerun to provide updated prices. It is the purpose of the FPMC to update permanently the coefficients of the allocation models during the implementation of the project through the feedbacks 2 and 4.

CORRECTION OF CASH FLOWS

Every period, the cash flow table is updated in function of incurred costs and revenues. Historical data are entered and eventually new forecasts (short and/or long term) are rerun based on new information and trend. The more advanced the implementation of the project becomes, the more likely the decision maker is to be able to make precise forecasts of cash flows. This is due to the experience he has acquired and to the additional availability of information from historical data. The situation shifts from uncertainty to risk.[1] Reducing the errors in estimates is a worthy objective, but no matter how much risk quantification of the future goes into a capital investment decision, when all is said and done, the future is still the future. Therefore, however well one forecasts, one is still left with the certain knowledge that not all uncertainty can be eliminated and feedback corrections will be required periodically no matter what. It is the function of the management information system (MIS)(Block C) to make those periodical corrections of the cash flow table.

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[1]Uncertainty is distinguished from risk by the inability to assign probabilities to future states.

MANAGEMENT DECISIONS

Once in posession of estimated and actual revenues and cost figures, the decision maker has to analyze their differences. When changes occur which negate or significantly alter previous assumptions or forecasts, the manager must then consider the changes indicated by the evaluation of his ongoing project.

The FPMC provides a means to determine whether or not actual costs and benefits were overestimated or underestimated. Cost overruns and/or overestimation of benefits may lead to a decision to pursue an alternative course of action to meet the goals set for the project. The blocks previously discussed in the proposed model (A, B) and the correction of cash flow (C) are needed to obtain the information required to make the right management decisions at the individual benefit or cost level (Block D of the FPMC). Management decisions at this stage require the determination of whether or not the variances between the actual and estimated benefits and costs of a project are significant. If a variance is significant future costs and benefits must be revised. The final decision consists in determining whether or not the whole project has to be continued (Block E).

The variances between the standard budget (appraisal or cash flow table from the preceding period) and the actual figures, can be assessed using either statistics or value judgments. In either case a control chart should be designed which includes two control limits within which deviations from the standard are attributable to chance causes. The cost and revenue control chart is thus made up of three different zones:

(1) a zone of good performance located within the control limits,
(2) a zone of poor performance found above the upper control limit. When actual data fall in this area unfavorable causes are present and action must be taken to eliminate them, and
(3) a zone of excellent performance located below the lower control limit. A point falling in this area shows that a particular current cost is more favorable than expected. In this case an effort should be made to perpetuate the favorable cause. If the control limits were not set realistically the limits have to be reestablished.

Those charts primarily serve as easily maintained warning devices. An important aspect of charting is to force continual comparison of actual and forecasted values during updating. The time to recognize change is while it is occurring.

The statistical control chart is based on the well known statistical principle that significant variances are those that do not arise purely through chance circumstances. Consequently the tolerance range should be sufficiently wide to accomodate variations from standards that are purely due to chance. Each time an observation is encountered that is outside the confidence interval, a decision must be made. By concentrating only on those deviations attributable to controllable causes, and not to chance, the manager will develop maximum efficiency in controlling his project.

When nonstatistical control charts are used, the usefulness of such a device will depend on the expertise and experience of the manager in charge of the project. The only difference with a non-statistical chart is that the variance allowed in this case is generally not bracketed by a statistically established confidence interval. An arbitrary percentage variation from the standard is set as upper and lower limit. Such percentage variances can be useful but do not necessarily indicate the importance of the variance. Every operation or activity (e.g. plantations, road construction, logging, etc.) has some inherent variance due to chance causes or factors which are individually indeterminable, but which in their aggregate are of some importance. The only certain way to determine how much variance is significant is to apply a statistical test to the detailed data. Experience may substitute for the lack of statistical data.

Once these variances have been found significant, a decision is made, together with the people directly, responsible for a particular variation in cost and/or revenues, to change the project implementation taking these variances into account. The best course of action is chosen and a new cash flow table is constructed for the revised project. The information about this revised project will be fed up through feedback 2 to the allocation models (Block B) and through feedback 1 to update the new cash flow forecasts (Block C). Is this newly defined project still viable? The answer is not obvious. The manager of a forestry project is invited to use the alternative test considered in the last block of the FPMC.

THE ALTERNATIVE TEST

Once in possession of the revised project which includes historical costs and returns and new projections of cash flows, the manager needs to use a financial criterion to assess the adjusted profitability of the project. The NPW calculated taking the entire adjusted cash flow (historical data and new forecast) into consideration will be of limited usefulness for management purpose. It can tell the manager how far or how close he has been to the NPW set at the appraisal stage. Nevertheless, the record of successive overall measures of success of a project could be useful in ex-post analysis of forestry project. In centrally planned economies, those NPW or IRR's

calculated with sunk costs are assumed to contain full information about the possible success or failure of a project (Horvat, 1964).

By opposition to this full cost analysis, the marginal analysis will consider past costs and revenues as sunk. The historical costs and revenues are removed and the NPW is based only on the future cash flows of the project. In general for forestry projects, most of the revenues are collected toward the end of the project while the costs are incurred in the first few years. The resulting NPW will probably be quite high and so would not be very helpful in directing management action for the ongoing project.

The recommended test is the Alternative Test. This test has been explained elsewhere (Harou, 1978)[1]. Briefly, the NPW used in the marginal analysis is compared with the abandonment value of the project. If the abandonment value is higher the project is abandoned. The same test could be carried out with the IRR criterion. The cash earnings that will be lost if a project is discontinued are expressed as a rate of return on the disposable value of the assets that will be released if the decision is made to abandon the project. The rate of return is then compared with an alternative rate of return. If the indicated rate of return is lower than the alternative one, abandonment is indicated.

The abandonment value of a resource is equal to the true opportunity cost of the resource to the firm. This value could be determined in the market place (land value, resale value for equipment, etc.) or within the firm or agency. The abandonment value is the highest value of the sunk resources to the firm if it used them for some other purpose. The abandonment value then results from the analysis of alternative of the ongoing project. This is important since it implies that even during the project implementation phase, the collection of information regarding alternative investment opportunities is relevant. Consideration of alternatives is not restricted to the appraisal analysis of a forestry project. The alternative test forces management innovation and dynamism in the control process which emphasizes improvement of the actual project over blind control of negative variance between actual performance and forecasted data.

It is worth noting here that the alternative test could be applied for a component of the multiple use project also. This is shown by the direction flow arrow between block E and D indicating that the decision made about changing the recreation component of the project, for instance, can be made by using the same alternative test.

If a project fails the abandonment or alternative test, one must look for some alternative implementation plans or abandon the project. The results of the alternative test must be consistent with the goal set by manager. While FPMC assumes a strict financial goal, other goals may be predominant. For example, a firm may want to maintain a forestry project below the profitability criterion because it provides a constant supply of pulpwood for a paper mill. In this case of conflicting goals it is important to enumerate and quantify all the relevant costs arising from the abandonment of the present project. In the case where the management of a pulp and paper industry decides to sell or to change the land use of its pulpwood production land, the cost resulting from a more uncertain pulpwood supply should be subtracted from the abandonment value of the project. If the recreation component of a multiple use project is deficitary, this forest outputs should be maintained if public involvement or political decisions require it. However, the manager has to make the cost/output clear to everybody.

CONCLUSIONS

The multiple use type of forestry projects are probably the most difficult to control and monitor because of the many interdependent outputs involved, the problem of product valuation, and the many constraints surrounding them.

The FPMC is a decision framework to monitor and implement such projects. The monitoring and control of past capital outlays are the most ignored step in the project cycle though one of the most important ones (Bailer and al, 1978). The model is useful in reducing uncertainty surrounding a given forestry project. By systematically monitoring forestry investment projects, planners can be in a position to take corrective action as soon as a significant deviation occurs between actual and estimated project data. The experience acquired by monitoring forestry projects will help to appraise better future projects and to reduce considerably many types of uncertainty and risks associated with forestry projects. It will also help to develop adequate contingency plans for the ongoing project and future similar forest investment. The model has managerial implications also. It is instructive for the manager to have feedback on previous implementation decisions in order to know the consequences such decisions have had on the profit and organization of the firm. Finally, the model insures a smooth transition from project appraisal to implementation.

The monitoring cycle model is not perfect. However, it focuses attention on the right questions which every manager should consider to implement properly and control multiple use forestry projects.

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1 The AT algorithm is included in Appendix I.

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APPENDIX I

The AT Algorithm

An algorithm expressing the AT is presented here (Robicheck and al, 1969): a) compute NPW of the project based on today's expectation and assuming abandonment in the last year of the project or compute $NPW_{\tau \cdot a}$ for a = n where

$$NPW_{\tau \cdot a} = \sum_{t=\tau+1}^{a} \frac{E[CF]_{t \cdot \tau}}{(1+r)^{t \cdot \tau}} + \frac{E[AV]_{a \cdot \tau}}{(1+r)^{a-\tau}}$$

the net present worth expressed in terms of current year τ assuming abandonment occurs in year "a".

- t = any given year beyond period τ.
- a = any year of possible future abandonment.
- n = the life of the project in years.
- $E[CF]_{t \cdot \tau}$ = expected cash flow in year t as of year τ.
- r = alternative rate of return
- $E[AV]_{a \cdot \tau}$ = expected abandonment value in year a as of year τ.

(b) If $NPW_{\tau \cdot n} > AV_\tau$, where $NPW_{\tau \cdot n}$ is $NPW_{\tau \cdot a}$ for a = n and AV_τ is the current abandonment value, continue the project and evaluate it again at time $\tau + 1$, based upon expectations at that time.

(c) If $NPW_{\tau \cdot n} \le AV_\tau$, compute $NPW_{\tau \cdot a}$ for $a = n - 1$.

(d) Compare $NPW_{\tau \cdot n-1}$ with AV_τ as in (b) and (c) above. Continue the procedure until either the decision to continue the project is reached or $a = \tau + 1$.

(e) If $NPW_{\tau \cdot a} \le AV$ for all $\tau + 1 \le a \le n$, then abandon the project at time τ. An example is given in Forest Industries, Harou 1980.

Two points are worth noting to clarify the meaning of this algorithm. First the model allows for an optimal timing of the abandonment decision. In other words, it considers the possibility that future abandonment may be more desirable than either present abandonment or continuation of the project to the end of its economic life. The consideration of deferred abandonment is important in the situation where AV and expected future cash flows do not decline rapidly over time or even increase as it is the case in most forestry projects.

Secondly, the situation in which one considers future possible abandonment beyond the present period holds only under condition of certainty with respect to both future cash flows and AV. However, one usually works under conditions of uncertainty in forestry primarily because of the long time span of these projects. For this reason if $NPW_{\tau \cdot n} > AV_\tau$ the model proposes to evaluate the project again at time $\tau + 1$, based upon expectations at that time. In period $\tau + 1$ we will have more insight about probable AV and cash flows. It may be that in period $\tau + 1$ we will be able to assess some probability on both AV and cash flow for the remaining period of the project. By advancing in the life of the project we progressively pass from uncertainty to a situation of risk. Uncertainty is distinguished from risk by the inability to assign probabilities to future state.

LA OBSERVACION DEL COMPORTAMIENTO DE PROYECTOS FORESTALES DE USO MULTIPLE

La gestión de los proyectos con pautas múltiples es un proceso dynámico, y la evaluación inicial del proyecto está raramente puesta en práctica como tal. Los cambios comparativemente a la primera evaluación están frequentes, y de esto sucede la necesidad de establecer una metodología de control desde la primera fase de implementación del proyecto.

Una comparación periódica de las actividades planificadas y realizadas, y también una comparación de los costos y beneficios antes y durante la realización del proyecto tienen que ser integradas en un modelo de control periódico. (The forestry Project Monitoring Circle). Este modelo permitirá el encargado del proyecto de reaccionar rápidamente a toda diferencia juzgada "anormal". Finalmente, el "test de Alternativa" tiene que ser aplicado para decidir si el proyecto tiene que seguir como tal, o con cambios, o si tiene que ser abandonado.

CONTROLE DE LA PERFORMANCE DES PROJETS DE L'USAGE MULTIPLE DE LA SYLVICULTURE

La gestion des projets à but multiple est un procédé dynamique et l'évaluation initiale du projet est rarement mise en pratique telle quelle. Les changements par rapport à l'évaluation première étant la règle plutôt que l'exception, il est primordial d'établir une méthode de contrôle dès la première phase de la réalisation du projet.

Une comparaison périodique des activités plannifiées et réalisées de même qu'une comparaison des coûts et revenus avant et pendant la réalisation du projet doivent être structurées dans un modèle de contrôle périodique. (The Forestry project Monitoring Circle). Ce modèle permettra au décideur de réagir promptement à tout écart jugé "anormal". Le test d'Alternative doit finalment être appliqué pour pouvoir juger si le projet doit être continué tel qu'il est, moyennant changement ou pas du tout.

UBERWACHUNG DER AUSFUHRUNG VON VIELFALTIGEN FORSTNUTZUNGSPROJEKTEN

Weil die Verwaltung der mannigfaltigen Anwendung der Forstkultur ein dynamischer Prozess ist, werden die Projekte selten gemäss ihrer ursprünglichen Einschätzung oder gemäss des geplanten Verfahrens eingesetzt.

Da Änderungen eines Projektes sehr oft vorkommen, ist es wichtig, dass bereits frühzeitig eine vorsichtige Überwachung des Projektes eingeführt wird.

Periodische Vergleiche der geschätzten und eigentlichen Kosten, sowohl auch das Einkommen sollten es dem Entscheidenden ermöglichen, schnell auf unerwartete Abweichungen zu reagieren.

Während der Planung sollte der "Alternative Test" dazu dienen, die Gewinnchance des Projektes ganz oder teilweise abzuschätzen.

Determining Timber Harvesting Costs Consistent with Forest Utilization Limitations in Forests Used for Recreation[1]

Heikki Vesikallio[2]

Abstract. The paper presents the principles applied in the planning of recreational areas, the environmental wishes of the users of recreational areas, their observance in the use of forests, and the determination and amount of the resulting additional costs in timber harvesting.

According to summary calculations made in Finnish conditions, thorough consideration of the environmental wishes of the users of recreation areas in the treatment of forests increases in the present situation the timber harvesting costs by 10-50 % depending on the conditions.

GENERAL

As urbanization progresses an increasing proportion of the population tries to spend its leisure time out in the open. The increase in spare time, better communications and the rise in real incomes improve the chances of physical recreation. These phenomena of social change are increasing the value of forests as a recreational environment.

It is worth while in economic planning to reserve a certain forest area for recreation if the value of the benefits of recreational use is greater than the alternative costs in the best alternative use. The alternative costs of recreational use in the commonest case consist of the loss of wood production and harvesting that results.

THE OUTDOOR RECREATION AREA GROUPS

So far few studies have been made in North Europe concerning the value of forests used for recreation. Neither has the financial loss caused by using them for recreational purposes been studied in detail from the point of view of timber production and harvesting. Therefore, when the need for recreational areas has been considered in connection with regional and town planning, it has been necessary to start from certain area standards per inhabitant, based on the number of the population. The general data on the outdoor recreation area groups proposed for Finland are given in Table 1.

Table 1. Outdoor recreation parks, outdoor recreation areas, excursion areas and rambling areas in the outdoor recreation area system in Finland

Type of outdoor recreation area	Intended use	Location and accessibility	Service equipment
Outdoor recreation park	Mainly for the free time of an urbanized population. Facilities for walking, being out of doors, ball games, and playing.	Within an urbanized area. Max. 5 min. walking access. Distance max. 1.5 km.	Playground, lighted pathways, grass playing field for ball games.
Outdoor recreation area	Mainly for the free time, especially at weekends, of an urbanized population. Facilities for exercise, hikes and being out of doors.	Within or adjacent to an urbanized area. Undisturbed access by foot, or by public transport. Max. time required 15—20 min., max. distance 2—10 km.	A network of footpaths, organized servicing.
Excursion area	An area catering mainly for weekend recreation. Facilities for being out of doors and exercising in natural surroundings, nature hobbies, pathfinding and skiing, etc.	Accessible by public transport. Max. time required 1.5 hours max. distance 20—120 km.	One or more bases where camping is possible. A network of signposted footpaths.
Rambling area	An extensive, wilderness type of recreation area for outdoor activities, often rated as a nature reserve, intended for holiday use. The accessibility of the area is not an important factor.	Access by public transport.	Facilities for hikes lasting several days. Signposted trails, wilderness huts or cabins provided.

[1] Paper presented at the IUFRO/MAB Conference: Research on Multiple-Use of Forest Resources, May 18-23, 1980, Flagstaff, Arizona.

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THE ENVIRONMENTAL WISHES OF THE USERS OF RECREATION AREAS AND THEIR CONSIDERATION IN THE USE OF FORESTS

In studying the wishes of the users of outdoor recreation areas, their diversity and variety, beauty, natural state, accessibility and the wealth of their fauna are valuable general properties to consider for recreational purposes. Factors marring the scenery are the scars of burning-over, soil preparation, uncleaned young forest stands, the effect of hormonal pesticides in a hardwoods coppice and wide unbroken clear-cutting areas, etc.

Diversity and variety are added to the forest scenery by, e.g., preserving a part of the stands in their natural state. Another method is to avoid the formation of unbroken large stand compartments. Clear-cutting areas of over 2 hectares were regarded as a disturbing factor in opinion polls. Variation in the forest scenery is increased also by the presence of stands of different ages composed of different tree species.

The beauty of the forest scenery can be increased by favouring pine and deciduous species as they are generally considered to be more beautiful than spruce. Burning-over, preparation of forest soil and the use of chemicals should be avoided. The most important requirement for timber harvesting is that the methods used damage the residual growing stock as little as possible. The stand boundaries and variation of tree species should conform with the topography. Special attention must be devoted in the creation of the cutting areas to points of terrain that constitute a part of a wider view.

Old pine stands meet the accessibility requirements best. It is also important for accessibility that logging residues are recovered from the cutting area and hikers' trails. Growing the forests thinly also improves accessibility.

Observing the environmental wishes of the users of outdoor recreation areas weakens the harvesting conditions so much compared with wood-producing forests proper that the use of multipurpose logging machines cannot be considered. Timber harvesting must be done chiefly in conditions of selective thinning. The primary criterion for the choice of the harvesting method must be that it causes the smallest possible damage to the residual growing stock. The shortwood system is the best of the harvesting alternatives in this respect and timber must be prepared manually.

Finnish studies on forest haulage methods have revealed that the nature of the harvesting equipment (farm tractors or forwarders and their size) makes no essential difference to the origination of damage. The use of, for instance, light machines in thinnings does not necessarily reduce the risk of damage. On the other hand, performing the timber harvesting during the winter and the use of a sparse strip road network and a sufficiently wide strip road (4-5 m) help to limit the extent of damage. Horse-haulage often causes even less damage than that caused by the preparation of timber.

ADDITIONAL COSTS CAUSED BY THE FOREST USE RESTRICTIONS IMPOSED BY THE RECREATIONAL USE OF FORESTS

The following data on the additional costs arising in timber harvesting from the recreational use of forests are based on the results of calculations made in the 1970s on actual forest areas in Finland. The investigation areas selected were forest areas whose natural conditions and accessibility made them suitable for excursion purposes. Alternative 10-year logging plans were drawn up for these areas based on their use as excursion forest or wood-production forest.[3] The logging plan for the excursion forest alternative observed the environmental wishes of the users of the outdoor recreation areas as far as possible. Normal principles of the management of commercial forests were applied in the preparation of the allowable cut plan for the wood-production forest alternative.

In calculating the costs for excursion forests, harvesting systems based on the use of either horses or small forest tractors were always applied.

For timber-producing forests the cost of harvesting was calculated according to all the alternative methods available. The following systems were included in the calculations:

Harvesting system 1. Felling, delimbing and bucking by chain-saw, forest haulage by forwarder.

System 2. Felling and delimbing by chain-saw, forest haulage by skidder, landing-site bucking by chain-saw.

System 3. Felling, delimbing and bucking by harvester, forest haulage by forwarder.

System 4. Felling by chain-saw, delimbing and bucking by processor, forest haulage by forwarder.

The comparison of the excursion forest costs and the timber-producing forest costs was based on the assumption that the cheapest har-

[3] Vesikallio, Heikki. Development Prognosis of Wood Harvesting in Finland for the Years 1978-1987. Julkaisuja Research Report 1, 73p. 1974.

vesting system was always used for the timber-producing forest. A special computer programme[4] was designed for the calculation of the costs.

According to the investigation results, harvesting costs at 1980 values were an average of about 40 % higher in an excursion forest than in a wood-production forest when the harvesting system in the excursion forest was a logger and a horse. When timber was harvested in an excursion forest by a schedule consisting of a logger and small forwarder, the harvesting costs were an average of about 15 % higher than those in a wood-production forest.

However, the additional costs due to the restrictions imposed by recreational use vary considerably in different areas with the natural conditions and the composition of the growing stock. Finnish studies give a 2-52 % range of variation for additional costs.

The additional costs caused by the restrictions imposed by recreational use will grow steadily as timber harvesting is mechanized.

In addition to the growth of harvesting costs, the logging potential also decreases because of the limitations imposed by recreational use. Wood yield has been estimated to be approx. 60 % smaller in outdoor recreation parks and areas in Finland than in wood-production forests proper in the same growth conditions. Wood yield has been estimated to be about 20 % smaller in excursion forests than in wood-production forests.

[4] Vesikallio, Heikki. The Increase in Timber Harvesting Cost as a Result of Forest Utilization Limitations. Univ. of Helsinki, Dept. of Land Use Economics, Research Report 1.

SUMMARY

The partial conflict between the recreational and wood-producing functions of forests creates the following problems in the planning of recreation areas:

To what extent should forest resources be transferred from wood-production to recreational use?

Which of the area alternatives should be reserved as recreation areas when they differ in recreational value and the costs caused by recreational use?

It is essential in reserving areas for recreational use to solve the problems associated with, e.g., the distribution of the financing responsibility, the ownership of the recreational areas and determination of the compensation payable to the forest owners.

There are unfortunately few empirical studies available from which to establish the standards needed in practical planning for the recreational value and alternative costs of recreational areas. This has caused in Finland a situation in which the planning of recreational area has been carried out of necessity on discretionary bases and the different interest groups have been unable to agree on them.

DETERMINACION DE LOS COSTOS DE COSECHAR MADERA CONSISTENTE CON LAS LIMITACIONES DE LA UTILIZACION DE LOS BOSQUES EN BOSQUES USADOS PARA PROPOSITOS RECREATIVOS

El conflicto parcial entre funciones de recreo y de producción de madera en los bosques crea los siguientes problemas en el planeamiento de las áreas de recreo.

¿Hasta qué punto deberían ser los recursos forestales transferidos de la producción de madera al aprovechamiento recreativo?

¿Cuáles de las alternativas del área deberían ser reservadas como áreas recreativas cuando hay diferencias en valor, y el costo se debe al aprovechamiento recreativo?

Al reservar áreas de aprovechamiento recreativo es esencial resolver, por ejemplo, los problemas asociados con la distribución de la responsabilidad monetaria, el dominio de las áreas recreativas y la determinación de la compensación pagadera a los dueños de los bosques.

Desafortunadamente, hay pocos estudios empíricos disponibles de los cuales se puedan establecer las normas necesitadas para planear prácticamente para el valor recreativo y costos alternativos de áreas recreativas. En Finlandia, esto ha causado una situación en la cual el planeamiento del área recreativa se ha llevado a cabo según la necesidad de bases discrecionales, y los grupos de diferentes intereses han sido incapaces de concordar en ellas.

COMMENT DETERMINER LES COUTS DE LA PRODUCTION DE BOIS DE CONSTRUCTION DE FAÇON COMPATIBLE AVEC LES LIMITATIONS DE L'UTILISATION DES FORETS DANS LES FORETS UTILISEES POUR LA RECREATION.

Le conflit partiel entre deux fonctions des forêts, récréation et production de bois, crée les problèmes suivants lorsqu'on envisage de créer des sites de récréation:

Dans quelle mesure les ressources forestières devraient-elles passer de la production de bois à l'usage récréatif?

Comment choisir les terrains qui devraient être gardés comme terrains de récréation quand ils ont des valeurs différentes du point de vue récréation et dépenses causées par leur emploi comme terrains de récréation?

Il est essentiel en classant ces terrains de récréation de résoudre les problèmes qui y sont associés, par exemple, la distribution des responsabilités financières, la propriété de ces terrains et le montant des sommes payées aux propriétaires de forêt expropriés.

Il y a malheureusement peu d'études empiriques disponibles d'après lesquelles on pourrait déterminer les critères nécessaires pour faire des plans pratiques pour la valeur de récréation et les différents coûts des terrains de récréation. Cela a créé en Finlande une situation où les études des terrains de récréation ont été forcément faites selon des méthodes arbitraires et les différents groupes d'intérêts ont été incapables d'arriver à un accord là-dessus.

AUFSTELLUNG VON HOLZERWERBUNGSKOSTEN, DIE DEN BEGRENZUNGEN DER FORSTNUTZUNG IN WALDERN RECHNUNG TRAGEN, WELCHE FUR ERHOLUNG BENUTZT WERDEN

Der teilweise Konflikt zwischen der Notwendigkeit für Erholung und Holzproduktion der Forsten bereitet folgende Probleme für die Planung von Erholungsstätten:

Bis zu welchem Grade soll die Holzproduktion den Erholungsbedürfnissen weichen?

Welche möglichen Gebiete sollen als Erholungsstätten zurückgestellt werden, wenn der Wert der Erholung und die von der Erholung verursachten Kosten nicht übereinstimmen?

Es ist wichtig bei der Zurückstellung von Gebieten für Erholungszwecke die Probleme zu lösen, die mit folgenden Beispielen zusammenhängen: Verteilung der finanziellen Verantwortlichkeit, Besitzrechte der Erholungsstätten und Festlegung von Ausgleichszahlungen an den Forstbesitzer.

Unglücklicherweise gibt es wenige empirische Untersuchungen, die helfen könnten, Richtmasse für Erholungswerte und mögliche Kosten der Erholungsstätten aufzustellen, die für die praktische Planung notwendig sind. Das hat in Finland eine Situation geschaffen, in der die Planung von Erholungsstätten, aus der Notwendigkeit heraus, auf willkürlicher Basis stattfand, und die verschiedene Interessengruppen nicht in der Lage waren, einstimmig zu entscheiden.

Recreation and Multiple Use of Forests, Parks, and Preserves: An Interface Between Man and the Ecosystem[1]

Roy W. Feuchter and George H. Moeller[2]

Abstract.--Recreation is legally established as a multiple use of forest land. A review of past research reveals several ways to compare resource outputs so that noncommodity values can be effectively included in land management planning. But better methods to value noncommodity outputs will be needed in the future.

INTRODUCTION

Recreation has long been recognized as one of the multiple uses of forests, parks, and preserves. In the USDA Forest Service, it is so recognized by law, under the Multiple Use and Sustained Yield Act of 1960 (16 U.S.C. 528-531). In actuality, though, recreation is one of the multiple uses of natural resources everywhere, because it plays an important role in satisfying human needs. The need to "re-create" has long been recognized as a basic need of man, thereby contributing significantly to physical and mental health of the Nation. In the U.S., Recreation also serves as an important generator of economic growth through annual expenditures of an estimated $180 billion in leisure-related purchases.

RECREATION AND MULTIPLE USE

Many of the basic human needs that can be fulfilled through participation in recreation can most effectively be supplied by outdoor recreation in a natural setting of forests and associated open space resources. However, the quality of recreation experiences that can be achieved are directly related to the opportunities and environments provided or maintained by forest resource managers.

Under the multiple-use mandate, managers of publicly owned forest resources are expected to optimize production of goods and services to best meet identified needs, opportunities and concerns. In developing programs to respond to this mandate, managers and planners must have a basis for comparing the relative values of all possible resource outputs and combinations of outputs. The growing importance of recreation and other noncommodity forest products, such as scenic beauty, wilderness, and nongame wildlife, has resulted in an immediate need to develop better systems with which to compare and assess the value of outputs from alternative management systems.

Most tools that are available to resource managers for manipulating environmental conditions are applied through management programs intended to produce forest products other than recreation. Just as ecological considerations must be an integral part of management planning for activities such as timber harvesting, watershed restoration, wildlife habitat improvement and fire management, so must the planning for recreation opportunties and benefits be included.

In order to optimize all benefits that can be obtained through land management, recreation managers must be able to have meaningful input into the land management and planning process. Due to the difficulties involved in assessing recreation benefits and equating input investment costs to output measures for multiple production goals, no system has yet been devised to consistently array quantitative natural resource investment opportunities. Some progress has, however, been made toward assessing noncommodity values. For example, many years of sustained research effort by Brown et al., (1979), has culminated in a new procedure that facilitates incorporation of recreation resource planning into the comprehensive land management planning process, as used by the Forest Service. The planning process is called Recreation Opportunity Planning and is based on the

[1]Paper presented at the IUFRO-MAB Conference on Research on Multiple Use of Forest Resources, Flagstaff, AZ, May 18-23, 1980.

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concept of evaluating recreation opportunities for the spectrum of activities that a given land unit could sustain.

The recreation opportunity spectrum concept grew out of the concern that recreation benefits should be evaluated because most publicly provided outdoor recreation opportunities have not been allocated by competitive market prices. Further, as Land Management Planning requirements have increased and conflicts in resource demands have accelerated, the planner's need to measure recreation benefits has also increased. Therefore, researchers worked to get better measures of both the economic and noneconomic benefits of outdoor recreation. They began by using survey research techniques to identify the reasons why different types of outdoor recreationists decide to participate in particular kinds of activities, and to quantify the kind and level of benefits that people felt they derived from such participation. This research led to development of an outdoor recreation opportunity resource inventory and management system that can be used to identify and map land areas on the basis of the specific types of recreation opportunities they can provide. The system has been adopted nationwide by the Forest Service and the Bureau of Land Management and is being incorporated into land management planning wherever use of resources for outdoor recreation is a management concern.

This process gives recreation managers a vehicle to incorporate research based knowledge into planning for multiple use management objectives. For example, once they determine the potential level of recreation opportunity, land planners can apply the results of other research such as recreation site impact evaluation (Magill and Leiser, 1967) to define the mix of forest land management prescriptions that will yield optimum cost-benefits for both recreation and other desired forest products within stated policy guidelines. Economic evaluations can also be applied at this point to consider feasibility and substitutability of recreation provided by the private sector (La Page and Cole, 1979).

Similarly, the research work of Twiss and Litton (1966) on landscape management principles is being applied in managing wildlife habitat and other forest land-related management activities such as powerline location and highway design, in addition to development of silvicultural prescriptions for timber management, in order that they can have minimal impact on the visual environment.

Research by Myklestad and Wagar (1976) has resulted in additional ways to reduce or minimize conflicts between timber harvesting activities and landscape values. Computer procedures have been developed that generate landscape views to show the short and long term visual effects of proposed landscape modifications, such as those brought about by timber harvesting. This research provides interim guidelines for reducing visual impact of many forest management practices and serves as a tool to minimize and evaluate environmental impacts. Computer-generated landscape views are currently being used to design timber sale layouts and will shortly become a useful tool to assess long term landscape values.

Research has demonstrated that recreation benefits, primarily for dispersed-type activities such as hunting, hiking, and nature observation, can be integrated with and, in some cases, derived as a noncompetitive byproduct from other forest land management activities, with no great reduction in other resource outputs.

Although these benefits have been recognized and to some degree identified on a local or project-by-project basis during the last several years, the Forest Service has now detailed these results through the national RPA planning process which responds to the requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974, (U.S.C. 1600-1614). In the planning process, five alternative program levels were developed. Each of these levels carries its own costs and outputs and provides the basis for some judgements on recreation benefits. For example, the highest level indicates that outputs will be approximately 77 percent higher than the outputs of the lowest level, while the costs will be 115 percent higher. This discrepancy in relationships is described in terms of social differences in the recreation programs such as variations in the quality of the experiences. From this, it is found that outputs alone, as presently measured, cannot provide the complete cost/ benefit scenario for any given program level. Rather, the social benefits must also be considered in the decision process in determining the optimum program level or mix. However, these social benefits are still subjective, and, therefore, more quantifiable social measures are still needed as the next step in development of recreation cost-benefit analysis.

RESEARCH NEEDED FOR BENEFITS EVALUATION

While this RPA planning effort is significant in the application of cost-benefit analysis to multiple use decisionmaking, it is admittedly weaker with regard to the recreation component than to most other forest product components. Experience with trying to evaluate

recreation in relation to other forest land outputs has, in fact, high- lighted the need for better output measures for recreation, as well as the need to demon- strate the true value of benefits derived from outdoor recreation participation. This is important to recreation planning and decisionmaking; perhaps the most important research need that planners and managers now have. Such research must be guided by three considerations:

First, outputs must be linked to inputs so that direct cause and result determinations can be made. This will provide the foundation on the cost side for quantitative cost/benefit comparisons.

Second, outputs must relate to user needs for the benefit side. We should recognize that user needs are different from demands. By this we mean that the decision maker has a responsibility to determine, evaluate, or estimate national needs as differentiated from national or public demands or desires. We should realize that there is only one real reason to be concerned about recreation output measures, and that is to determine if people's needs for natural resource-based outdoor recreation are being met, and if these needs are real. Most recreation managers, of course, believe strongly that such needs exist -- and that these needs are nearly as important to most societies as are needs for food and shelter. They believe that recreation provides a socially acceptable way for peopleto adapt and adjust to the increasing pressures of urbanization, specialization, and modernization; and of crisis problems such as energy shortages and economic declines. But we need data to support this belief if it is to be given proper recognition.

Third, if we are willing to accept on faith that natural resource-based outdoor recreation is important, we can argue that policy makers and wildland managers have not yet recognized its true value and importance. At least part of the reason for this lack of recognition is that we have no descriptive, responsive output measures to use to help demonstrate that importance. Without such demonstration, it is only logical that policy makers do not, and, in fact, cannot support ongoing and proposed programs to coordinate recreation management with other "multiple uses" that have better defined cost/benefit measures. As a result, the public is being deprived of needed recreation opportunities.

SUMMARY

Recreation has long been recognized as a multiple use of forests, parks and preserves. The quantity and quality of recreation provided is directly related to whether or not all forest resource outputs can be compared to evaluate multiple use investment opportunities. But no way has yet been found to quantitatively array alternative forest resource investment opportunities. Progress has, however, been made toward evaluating benefits from recreation and relating these benefits to resource characteristics. Research has also developed methods to assess landscape values and to reduce some conflicts among resource uses in order to produce joint products.

National resource planning has included an attempt to apply benefit/cost analysis in multiple use planning. This analysis is weakest with regard to the recreation component. Needed research to better identify and quantify outdoor recreation benefits for planning must be guided by three considerations: outputs must be linked to inputs; outputs should relate to human needs; and recreation output measures must be consistent with other measures of resource productivity and capability.

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LA RECREACION Y LA UTILIZACION MULTIPLE DE BOSQUES, PARQUES Y RESERVAS: UNA CONFRONTACION ENTRE EL HOMBRE Y EL SISTEMA ECOLOGICO

La recreación ha sido largamente reconocida como el uso múltiple de los bosques, parques, y reservas. La cantidad y la calidad de la recreación provista están en relación directa con la comparación que puede o no llevarse a cabo de toda la producción de los recursos forestales para evaluar la utilización múltiple de las oportunidades de inversión. Pero no se ha encontrado todavía la manera de ordenar cuantitivamente las alternativas de los recursos forestales para oportunidades de inversión. Se ha hecho un adelanto, sin embargo, en la evaluación de los beneficios de la recreación, relacionando estos beneficios con las características de los recursos. Se ha elaborado métodos mediante la investigación para determinar la importancia de los paisajes y para reducir algunos conflictos que existen en la utilización de los recursos para producir resultados comunes.

El planeamiento de los recursos nacionales ha hecho un intento de aplicar el análisis del costo/beneficio en la planificación de la utilización múltiple. Este análisis es incompleto con respecto al componente de la recreación. La investigación necesaria para identificar mejor y determinar los beneficios de la recreación al aire libre con miras a la planificación debe estar guiada por tres consideraciones, que son: la producción debe estar vinculada al consumo; la producción debe estar relacionada con las necesidades humanas y las medidas del rendimiento de la recreación deben ser consistentes con otras medidas de la productividad y de la capacidad de recursos.

LES LOISIRS ET LES EMPLOIS MULTIPLES DES FORETS, DES PARCS ET DES RESERVES: UN POINT DE CONTACT ENTRE L'HOMME ET L'ECOSYSTEME

Les loisirs, on l'a reconnu depuis longtemps, constituent un emploi multiple des forêts, des parcs et des réserves. La quantité et la qualité des loisirs fournis sont en rapport direct avec la comparaison que l'on peut mener ou non des ressources totales de la forêt pour évaluer les possibilités d'investissements à usages multiples. Mais il reste à déterminer comment on peut exprimer quantitativement les différentes possibilités d'investissements en matière de ressources forestières. On a toutefois fait des progrès vers une évaluation des avantages induits par les loisirs et vers la détermination des rapports entre ces avantages et les caractéristiques des ressources. La recherche a également dégagé des méthodes d'évaluation des valeurs du paysage et a permis de résoudre certains conflits entre emplois des ressources. de façon à dériver des produits communs.

La planification des ressources nationales a inclus une tentative d'application de l'analyse coûts/avantages à la planification des emplois multiples. C'est en ce que concerne les loisirs que cette analyse est la plus faible. La recherche ayant pour but de mieux identifier et mieux quantifier les avantages découlant des loisirs en plein air, en vue de la planification, doit être guidée par trois considérations: les produits doivent être reliés aux facteurs de production; et les mesures de produits de loisirs doivent être cohérentes avec les autres mesures de productivité et de capacité des ressources.

ERHOLUNG UND VIELFAELTIGE NUTZUNG VON WAELDERN, PARKS UND SCHUTZGEBIETEN: EINE WECHSELWIRKUNG ZWISCHEN MENSCH UND EKOSYSTEM

Erholung war lange Zeit anerkannt als vielfaeltige Nutzung von Waeldern, Parks und Schutzgebieten. Die Quantitaet und Qualitaet der vorhandenen Erholungsmoeglichkeiten steht im direkten Zusammenhang zu der Frage, ob die Ausbeute der gesamten Waldbestaende verglichen werden kann, um vielfaeltige Investitionsmoeglichkeiten auszuwerten. Es ist bis jetzt noch kein Weg gefunden worden, um eine quantitative Aufstellung von Investitionsmoeglichkeiten in Waldbestaenden zu erreichen. Es ist jedoch ein dahingehender Fortschritt erzielt worden, dass Vorteile der Erholung untersucht worden sind und diese Vorteile in Verbindung mit den typischen Eigenschaften der Erholungsquellen gebracht worden sind. Die Forschung hat ebenfalls Methoden zur Schaetzung des Wertes von Landschaften und zur Verringerung einiger Konflikte unter den Rohstoffnutzungen mit dem Zweck, gemeinsame Produkte hervorzubringen, entwickelt.

Die nationale Rohstoffplanung hat einen Versuch, eine Kosten-Nutzen-Analyse bei der Planung des vielfaeltigen Gebrauchs vorzunehmen, eingeschlossen. Diese Analyse ist am schwaechsten im Hinblick auf die Erholungskomponente. Eine notwendige Untersuchung zur besseren Identifizierung und Quantifizierung des Nutzens der Erholung ausser Haus muss von 3 Ueberlegungen geleitet werden: Das Ergebnis muss mit der Eingabe in Verbindung stehen; das Ergebnis sollte auf die Beduerfnisse des Menschen bezogen sein; und die Erholungsmassnahmen als Folge der Ergebnisse muessen in Bezug auf andere Massnahmen der Produktivitaet und Leistungsfaehigkeit der Erholungsmoeglichkeiten konsequent sein.

Discussion Papers

Ervin Zube, Moderator
University of Arizona, USA

Richard Krebill, Moderator
Forest Service, USA

The following papers were presented during the discussion sessions:

- BAL S. RAMDIAL: Application of multiple use techniques to justify the protection of a mangrove swamp forest in Trinidad.
- C. CHANDRASEKHARAN: Multiple use forestry: Problems and projects in Asia and the Pacific.
- MUHAMMAD AFZAL CHAUDHRY and SALIM SILIM: Agro-silviculture in Uganda: A case study for Kachung Forest.
- EXEQUIEL EZCURRA and SONIA GALLINA: Joint management of deer and cattle.
- WALTER FRIGO: Relationship between environment and human activity in the Alpine territory.
- E. S. TELFER: Potential wildlife problems in Canadian forests managed for maximum biomass production.
- G. W. ANDERSON: Australian agro-forestry--(1) pines and pasture for profit, and (2) Eucalypts for salinity control.
- BACHIR KADIK: A brief view of the greenbelt in Algeria and its place in the fight against desertification.
- MAHMOOD IQBAL SHEIKH: Deltoides clone of poplar grows better than hybrids.
- HARRY G. SMITH: Costs and benefits of multiple use in British Columbia.
- ASHBINDU SINGH: The system approach to multiple use of forest resources.

The papers spanned a broad array of interests and issues in multiple-use research encompassing socio-phychological and economic values, agro-forestry practices, and biological resources management. The papers also represented diverse geographic interests including Africa (Kadik, Chandry, and Silim), Asia (Chandrasekharan, Sheikh, and Singh), Caribbean (Ramdial), Europe (Frigo), Australia (Anderson), and North America (Ezcurra, Gallina, and Smith). An underlying theme in nearly all of the papers was the need to engage those who depend upon the resources for their livelihood or other needs--e.g., farmers, forest workers, fishermen, recreational users--in the development of conservation and management programs.

RAMDIAL discussed a study of the social and economic benefits derived from multiple uses of a mangrove forest swamp in Trinidad. Standard survey research techniques and an opportunity cost approach were employed. The objective of the study was to provide a means for the perceptions and values of the layman to be considered in the decisionmaking process for the future of the mangrove forest swamp--conservation and maintenance of present multiple uses or conversion to a waterway for the transshipment of liquified gas by barge. The study identified substantial social and economic benefits that were derived from existing uses. The swamp is presently under consideration for designation as a national park.

CHANDRASEKHARAN's paper provided an important regional assessment that followed logically on the global analysis of multiple use practices and research needs presented by Dr. KING in the Conference Keynote Address. While a number of multiple-use forestry issues were addressed, the primary focus was on agro-forestry, including the agri-silvicultural/Taungya system, silvio-pastoral system, agri-silvio-pastoral system, and multi-purpose tree production systems. The author presented a number of regional research needs: silvicultural problems, including species and site selection, agro-forestry techniques, and control of pests and diseases; quantitative evaluation of non-market values; maximizing total productivity of the land; the interaction of crops and trees in the Taungya system; and the requirement for multi-disciplinary approaches to meet their research needs.

CHAUNDRY and SILIM presented a case study of the success of the Taungya system in Uganda. They explored the past history and development of the study site in Kachung Forest, current status, and techniques being employed. Based on these data, a very positive assessment of future potential for the Taungya system was presented. Techniques employed in their study were: examination of existing records; interviews with forest officials, forest workers, and local people in and around the forest; and physical observation of field work. The authors conclude that the Taungya system not

only provided higher yields of agricultural crops and faster growth rates of trees, but also produced desireable social outcomes in the form of better community development and organization. Social benefits are attributed to equity in site working conditions and walking distances, which contrast with the less equitable conditions associated with more scattered traditional communal farming.

EZCURRA and GALLINA reported on competition between deer and cattle in the Biosphere Reserve of La Michilia. Competition was analyzed through an analysis of diet overlay of deer and cattle. They found that these animals have different diets during the critical dry season and that joint management is possible. Furthermore, they suggest that overall meat production will be higher with joint management than with a single focus on cattle. They note, however, that peasants and ranchers need to be included in the development of conservation programs and be made aware of the facts if wildlife is to be managed for sustained long-term yields.

In the Alps of Central Europe, man has practiced multiple-use forestry for centuries. Still, as FRIGO indicates in his paper, heavy use has degraded the area considerably. To reverse this trend, programs are underway to safeguard remaining unimpaired areas, and to restore the balance of the environment and traditions of the alpine world thru favoring of nonconsumptive customs and uses.

TELFER compared the potential impact of four possible forest management strategies on wildlife and showed how knowledge of wildlife biology can be integrated into multiple-use analyses. Since increasing the intensity of forestry to maximize phytomass production has a negative influence on wildlife diversity, it was suggested that spatial diversity in forest culture may be necessary to maintain wildlife values.

ANDERSON shared results from Australia that indicate the compatibility of grazing in pine forests and the enhanced productivity achieved through inter-planting with leguminous forbs. He also has some very intriguing research on how Eucalypts can be used to lower troublesome saline surface water which is contaminating culinary water supplies in cities near agricultural lands. The usefulness of forestry appears to be bound only by our imagination and intuition!

Another outstanding example of the use of multiple-use forestry comes from Algeria in a paper by KADIK on how a greenbelt of forest-pasture lands is being cultured in a zone across Algeria to reverse the encroachment of the Sahara Desert into the agricultural croplands of the north.

SHEIKH presented evidence that Populus deltoides cv. I-63/51 is indeed a superior tree, with growth rates exceeding that of many promising hybrids. In agro-forestry, where economic return is crucial, selection of the best planting stock is paramount.

SMITH provided a very clear picture of the function and role of rational decisionmaking needed for wise use of natural resources. His paper examines forestry in British Columbia as an example which presents a strong case for obtaining better information on the benefits of multiple-use forestry. Without quantification of costs and benefits, it appears likely that conflicts between user interests will increase as competition for resources increases around the world.

SINGH provided a nice example of how a systems approach of modeling forest functions can be used to integrate the complex of factors involved in multiple-use forestry. With the help of simple mathematical models and linear programming, it is possible to quantify relationships needed to evaluate trade-offs. If applied with an adequate scientific basis, the system approach appears to be a logical way to proceed toward a balanced multiple-use program with maximized benefits.

Brief discussion periods followed each paper. The majority of questions and comments were addressed to a mix of social science issues and concerns, as well as biological and physical science. Perhaps the best summary of these discussions was presented by a participant's final statement that ". . . helping people to produce well is the best way to conserve our area."

Application of Multiple-Use Techniques to Justify Protection of a Mangrove Swamp Forest in Trinidad

Bal S. Ramdial
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APPLICATION OF MULTIPLE USE TECHNIQUES TO JUSTIFY THE PROTECTION OF A MANGROVE SWAMP FOREST IN TRINIDAD

The study demonstrates that the Caroni Swamp is a biological resource with tremendous real estate value and with multiple use benefits that are personal and societal in nature.

The personal benefits are derived when certain problem states of individuals, particularly temporary escape, the need to experience nature and for intellectual stimulation and achievement (fishermen) are resolved in part or fully by a visit to the swamp.

The societal or community benefits include the employment opportunities and income generated, the large quantities of protein food produced, the fish and wildlife supported, the aesthetics constituted and the protection it affords us from surging tides.

Because many of the figures have been estimated and extrapolated for a year, they should not be considered conclusive and absolute. They are merely indications of the magnitude of benefits that can be derived from certain resource uses which could fluctuate between seasons and the degree of management given to the swamp.

Notwithstanding this, the methods used represent a step forward in reflecting in the market place the worth of this poorly understood resource which has multiple use benefits.

LA APLICACION DE TECNICAS DE USO MULTIPLE PARA JUSTIFICAR LA PROTECCION DE UN PANTANO CON BOSQUES DE MANGLES EN TRINIDAD

Este estudio demuestra que el Pantano Caroni es un recurso biológico con tremendo valor en bienes raíces y con beneficios de aprovecho múltiple de naturaleza personal y social.

Los beneficios personales originan en la tranquilidad y el sosiego que una visita al pantano proporciona a muchos individuos. Esta experiencia de sentirse unido con la naturaleza también puede proveer el estímulo intelectual necesario al ser humano (se cita el caso de los pescadores).

Los beneficios sociales o comunales incluyen las oportunidades de empleo e ingreso, la producción de alimentos de proteína en grandes cantidades, el apoyo a la piscicultura y la fauna silvestre, la estética que se constituye y la protección que nos concede por cambios en la marea.

Debido a que muchas de las cifras han sido estimadas y extrapoladas de un año, no deberían de ser consideradas conclusivas y absolutas. Son simplemente indicaciones de la magnitud de beneficios que se pueden obtener de ciertos aprovechos de recursos que pudieran fluctuarse entre estaciones y por el grado de aprovechamiento del pantano.

Sin embargo, los métodos utilizados representan un paso adelante, reflejando en el mercado el valor de este mal-comprendido recurso, el cual tiene beneficios de provecho múltiple.

ANWENDUNG VON VIELFALTIGER NUTZUNGSWIRTSCHAFT, UM EINEN MANGROVESUMPFWALD IN TRINIDAD ZU ERHALTEN

Die Studie zeigt, dass der Caroni Sumpf ein biologisches Reservoir mit sehr grossem Grundbesitzwert und vielen Möglichkeiten für nützliche Gewinne ist, die dem Einzelnen und der Gesellschaft nützen.

Die persönlichen Gewinne bestehen darin, wenn gewisse individuelle Probleme bestehen, dass ein Besuch des Sumpfes diese zum Teil oder ganz befriedigen kann; zum Beispiel, zeitweise Flucht in die Natur, die Notwendigkeit, die Natur zu geniessen, für intellektuelle Anregung und Befriedigung (Angler).

Die Gesellschafts- und Gemeindegewinne schliessen Arbeitsmöglichkeiten und erzeugtes Einkommen ein, grosse Mengen von produzierter Proteinnahrung, Fisch und andere Tiere der Natur, die Naturschönheit, und der bereitete Schutz vor hoher Brandung.

Weil viele Werte geschätzt und auf Jahresbasis übertragen wurden, sollten sie nicht als endültig und absolut bewertet werden. Sie sind lediglich Anzeiger der Grösse der Gewinne, die von der Benutzung gewisser Naturschätze erhalten werden können, welche aber zwischen Jahreszeiten und der Intensität der Sumpfbewirtschaftung schwanken mögen.

Trotz dieser Beschränkung ist die angewandte Methode ein Fortschritt in der Bewertung des Marktpreises dieses wenig verstandenen Naturschatzes, der viele Gewinnmöglichkeiten darbietet.

L'APPLICATION DES TECHNIQUES D'EXPLOITATION DIVERSIFIEE AFIN DE JUSTIFIER LA PROTECTION D'UNE FORET DE MARECAGE DE MANGLIERS A TRINIDAD

Cette étude démontre que le marécage de Caroni est une ressource biologique qui possède une très grande valeur immobilière et dont les usages multiples peuvent profiter à la fois aux individus et à la communauté.

L'individu en tire un profit personnel quand certains problèmes personnels, surtout le besoin de s'évader temporairement, le besoin de vivre au contact de la nature, et d'être stimulé intellectuellement et de se réaliser (les pêcheurs), sont résolus en partie ou entièrement par une visite au marécage.

Les avantages pour la société ou la communauté comprennent la possibilité de création d'emplois, donc de revenus, la production de grandes quantités de protéines, les poissons et la faune qui y vivent, l'esthétique du lieu, et la protection qu'il nous offre contre les marées montantes.

Parce qu'un grand nombre des chiffres ont été simplement des estimations et des extrapolations pour un an, il ne doivent pas être considérés comme certains et absolus. Ils ne font qu'indiquer l'ordre de grandeur des profits qui peuvent être tirés d'une certaine façon d'exploiter la ressource qui peut fluctuer avec les saisons et le degré d'administration du marécage.

Malgré cela, les méthodes utilisées représentent un pas en avant en ce qu'elles montrent la valeur marchande de cette ressource mal étudiée qui offre des possibilités d'exploitations multiples.

Multiple-Use Forestry: Problems and Projects in Asia and the Pacific

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MULTIPLE USE FORESTRY: PROBLEMS AND PROSPECTS IN ASIA AND THE PACIFIC

This paper deals with the practices of multiple use forestry in Asia and the Pacific: shifting cultivation, agro-forestry, watershed management and mixed forest crops. In Asia, multiple use forestry is primarily to be considered as a component of rural development and as a key to improved land use.

There are several challenging problems - silvicultural and others - which need attention to promote multiple use forestry. Special focus is needed for rainfed areas and river catchments with a built-in sensitivity to human factor.

SYLVICULTURE A L'USAGE MULTIPLE: PROBLEMES ET PROJETS EN ASIE ET DANS LA PACIFIQUE

Ce document traite de l'utilisation multiple de la foresterie en Asie et dans le Pacifique: culture itinérante, agro-foresterie, l'aménagement des bassins versants et produits forestiers variés. En Asie, l'utilisation multiple de la foresterie est avant tout considérée comme un élément du développement rural et un facteur clé de l'utilisation améliorée de la terre.

Plusieurs aspects sont en compétition--silvicultural et autres--et l'attention doit y être portée pour promouvoir l'utilisation multiple de la forêt. Une attention spéciale doit être réservée aux zones de pluie, et des bassins de réception où le facteur humain est un élément difficile.

EL USO MULTIPLE EN LA SILVICULTURA: PROBLEMAS Y PROYECTOS EN ASIA Y EL PACIFICO

Este documento trata las actividades forestales de utilidad múltiple en Asia y el Pacífico: agricultura migratoria, actividad agro-forestal, manejo de hoyas hidrográficas y pluricultivo. En Asia, la actividad forestal de utilidad múltiple debe ser considerada primordialmente como un componente del desarrollo rural y como un factor clave para el mejoramiento del uso de la tierra.

Hay varios problemas desafiantes--silvícolas y otros--que necesitan atención a fin de promover la actividad forestal de utilidad múltiple. Especial atención se necesita para las áreas de cultivos de secano y hoyas hidrográficas muy sensibles a la intervención humana.

VIELFATIGE FORSTNUTZUNG: PROBLEME UND PROJECTE IN ASIEN UND DEN GEBIETEN AM STILLEN MEER

Dieses Papier behandelt die Praktiken der Mehrzweckforstwirtschaft (Multiple Use Forestry) in Asien und im Pazifischen Raum: Wandernder Waldfeldbau, Agroforstwirtschaft, Pflege des Wasserhaushalts und die Nutzung gemischter Forstprodukte. In Asien ist die Mehrzweckforstwirtschaft in der Hauptsache als Bestandteil der laendlichen Entwicklung und als Schluessel zur verbesserten Landnutzung anzusehen.

Verschiedene Probleme - sowohl waldbaulicher als auch anderer Art - stellen eine Herausforderung dar und beduerfen daher besonderer Beachtung bei Foerderungsmassnahmen fuer die Mehrzweckforstwirtschaft. Im Brennpunkt des Interesses stehen regenbewaesserte Landflaechen und Flussniederungen mit bessonderer Beruecksichtigung menschlicher Faktoren.

Agro-Silviculture in Uganda: A Case Study for Kachung Forest

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AGRO-SILVICULTURE IN UGANDA: A CASE STUDY FOR KACHUNG FOREST

Study of agri-silvicultural practice in Kachung Forest of Uganda shows that the practice leads to reduction in capital investment, increase in the net revenue earnings and an early establishment of pine plantation through faster rate of growth. Also the yield of agricultural crop is notably higher than "other lands". The practice improves the site by bringing in almost permanent ecological and socio-economic changes. The minimum and maximum period for allowing agriculture in the forestry crop has been assessed. The possibilities of improvement in agri-silviculture, which is still at a juvenile stage in Uganda, have been spot-lighted.

L'AGRO-SYLVICULTURE EN OUGANDA: UNE ETUDE DANS LA FORET DE KACHUNG

L'étude de la pratique de l'agro-sylviculture dans la forêt de Kachung montre que cette pratique mène à une réduction des investissements en capital, à l'augmentation du revenu net et à une plantation plus rapide de pins grâce à une croissance plus rapide. En plus, le rendement de la récolte agricole est bien supérieur à ceux d'"autres terrains". Cette pratique améliore le site en apportant des changements écologiques et socio-économiques presque permanents. La période minimale et maximale pendent laquelle l'agriculture est permise dans les récoltes forestières a été déterminée. Les possibilités d'améliorer l'agro-sylviculture, qui en est toujours à un niveau élémentaire en Ouganda, ont été mis en relief.

LA AGRI-SILVICULTURA EN UGANDA: UN ESTUDIO DEL BOSQUE KACHUNG

Estudios de prácticas agri-silviculturales en el "Bosque Kachung" en Uganda indican que la práctica conduce hacia una reducción en el capital de la inversión, aumento en las ganancias del ingreso neto y un establecimiento rápido de plantación de pinos a través de un grado rápido de crecimiento. También el rendimiento de la cosecha agrícola es notablemente más alto que en "otros terrenos." La práctica mejora el sitio efectuando cambios casi permanentes, ecológicos y socio-económicos. Se analiza el período mínimo y máximo para permitir agricultura en la cosecha forestal. Se anotan las posibilidades de progreso en la agri-silvicultura, la cual todavía está en un estado juvenil en Uganda.

AGRAR-FORSTWIRTSCHAFT IN UGANDA: EINE UNTERSUCHUNG DES KACHUNG FORSTES

Die Untersuchung der agrar- forstwirtschaftlichen Methoden im Kachung Forst von Uganda zeigt, dass die Methoden zur Verkleinerung von Kapitalinvestierung, Vergrösserung des Nettoeinkommens und eine frühzeitige Einrichtung einer Kiefernpflanzung zu grösserer Wuchsrate führt. Auch ist die Erzeugung von Agrarprodukten bedeutend grösser als die von "anderen Ländereien." Die Anwendung der Methode verbessert den Standort, indem sie beinahe fortdauernde ökologische und gesellschaftlich- ökonomische Veränderungen schafft. Der minimale und maximale Zeitraum für die Verbindung von Landwirtschaft mit Forstwirtschaft wurde bestimmt. Die Möglichkeiten der Verbesserung der Agrar- Forstwirtschaft, die noch immer in einem Jugendstadium in Uganda ist, wurden beleuchtet.

Joint Management of Deer and Cattle

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JOINT MANAGEMENT OF DEER AND CATTLE

In the Biosphere Reserve of La Michilia, at Durango, Mexico, the Instituto de Ecologia has been studying since 1975, the White-tailed deer population: food habits, population dynamics, carrying capacity and potential competition with cattle. Shrubs and trees are the main food, whereas the cattle eat mainly grasses and forbs. The competition for food during the dry and wet seasons was low. The deer show a strong preference for: Phoradendron spp, Pithecellobium leptophyllum and Baccharis conferta and consume a high proportion of Juniperus spp. and Quercus spp. due to their high availability. The species with the highest utilization values for cattle are: Muhlenbergia rigida, Bromus carinatus, Piptochaetium fimbriatum, Festuca tolucensis and Aristida schiedeana. Hence, the joint management of deer and cattle is possible and it can increase the income of ranchers and peasants.

ELEVAGE SIMULTANEE DU CERF ET DU BETAIL

Dans la Réserve de la Biosphère de la Michilía (Durango, Mexique), l'Instituto d'Ecologia a étudié, depuis 1975, la population du cerf a queue blanche: ses habitudes alimentaires, dynamique de la population, capacité de charge du milieu et possible rivalité avec le bétail bovin. Les arbustes et les arbres sont ses principaux sources d'aliments, tandis que le bétail se nourrit de pâtures et d'herbes. La rivalité pour la nourriture est faible, aussi bien à la saison sèche qu'à la saison des pluies. Le cerf préfère particulièrement: Phoradendron spp, P. leptophyllum et B. conferta et il consomme une importante proportion de Juniperus spp. et Quercus spp. a cause de leur disponibilité élevée. Les espéces qu'utilise principalement le bétail sont: M. rigida, B. carinatus, P. fimbriatum, F. tolucensis et A. schiedeana. Pour ces raisons l'élevage simultané de cerfs et de bétail est possible, ce qui permet une augmentation dans les revenus de paysans et de petits propriétaires.

MANEJO CONJUNTO DEL VENADO Y EL GANADO

En la Reserva de la Biosfera La Michilía en Durango, México, el Instituto de Ecología ha venido estudiando desde 1975, la población del venado cola blanca: sus hábitos alimenticios, dinámica de la población, capacidad de carga del medio y posible competencia con el ganado vacuno. Arbustos y árboles constituyen su principal alimento, mientras que el ganado consume pastos y hierbas. La competencia por el alimento es baja tanto en la época seca como en la de lluvias. El venado tiene particular preferencia por: Phoradendron spp, P. leptophyllum y B. conferta, y consume una alta proporción de Juniperus spp. y Quercus spp. debido a la alta disponibilidad. Las especies que más utiliza el ganado son: M. rigida, B. carinatus, P. fimbriatum, F. tolucensis y A. schiedeana. De ahí, que sea posible el manejo conjunto del venado y el ganado pudiendo incrementarse el ingreso de ejidatarios y pequeños propietarios.

GESAMTMANAGEMENT VON HIRSCH UND RINDVIEH

Seit 1975 studiert das Ökologieinstitut (Instituto de Ecología) in der Biosphärenreserve "La Michilía" im Staate Durango, in Mexiko, die Population des Weisswedelhirsches (Odocoileus virginianus): Ernährungsweise, Populationsdynamik, Umweltkapazität und mögliche Konkurrenz mit dem Rindvieh. Der Hirsch ernährt sich hauptsächlich von Sträuchern und Bäumen, während das Rindvieh Gräser und Kräuter nimmt. Es gibt eine geringe Konkurrenz der Ernährung wegen, während der Trokkenzeit sowie während der Regenzeit. Der Hirsch zeigt eine besondere Vorliebe für: Phoradendron spp, P. Leptophyllum und B. conferta und verzehrt eine hohe Proportion von Juniperus spp. und Quercus spp. wegen einer grossen Verfügbarkeit. Die Arten, die am meisten vom Rindvieh benutzt werden, sind: M. rigida, B. carinatus, P. fimbriatum, F. tolucensis und A. schiedeana. Deswegen ist ein Gesamtmanagement von Hirsch und Rindvieh möglich, so dass eine Einkommenzunahme durchführbar ist, für den Ejido (genossenschaftliches Nutzungssystem) und die Kleinlangeigentümer.

Relationship Between Environment and Human Activity in the Alpine Territory

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RELATIONSHIP BETWEEN ENVIRONMENT AND HUMAN ACTIVITY IN THE ALPINE TERRITORY

The settlement of Man in the Alps dates back to the palaeolithic period but the environment has been affected by his presence only since last century when he started "consuming" the mountainous regions by the intensive exploitation of their resources.

The surveys carried out by all Alpine States have shown that since the Industrial Revolution the whole alpine chain has been threatened by extinction because of the progressive deterioration of the natural character and of the integrity of its environment.

The need for an overall policy has been stressed in order to stop this trend. Such policy mainly lies in the recovery of the alpine world, of its traditional history and culture by restoring the balance of the deteriorated environment, by strictly safeguarding the unimpaired areas, by relaunching traditional human activities and by adopting a new kind of tourism that does not involve any further "consumption" of the territory.

RELACIÓN ENTRE MEDIO AMBIENTE Y ACTIVIDAD HUMANA EN EL TERRITORIO ALPINO

El asentamiento del hombre en los Alpes se remonta a la época paleolítica, pero su influencia sobre el medio ambiente se notó sólo en el último siglo; es decir desde que la actividad humana empezó su proceso de utilización del territorio montañoso, con la explotación intensa de sus recursos. Las investigaciones efectuadas por todos los Estados Alpinos demostraron ampliamente que al llegar la era industrial, el conjunto alpino fue amenazado de extinguirse a causa de la desaparición progresiva de la naturaleza y de la integridad del medio ambiente que lo constituye. Para cambiar esta situación se ha evidenciado la necesidad de una política global que prevee un plan cuyas líneas esenciales se basan en la recuperación del mundo alpino, de su historia y cultura tradicional, a través de intervenciones que restablezcan las zonas afectadas y que salvaguarden rígidamente las que todavía están íntegras. Se necesita además fomentar las actividades humanas tradicionales y plantear diferentemente la fruición turística de manera que no prevea una utilización ulterior del territorio.

RAPPORT ENTRE L'ENVIRONNEMENT ET L'ACTIVITE HUMAINE DANS LE TERRITOIRE ALPIN

L'établissement de l'homme dans les Alpes date du paléolithique mais ce n'est qu'au cours du siècle dernier que l'activité humaine a commencé à influencer l'environnement et à "consommer" le territoire montagneux par l'exploitation intensive de ses ressources.

Les enquêtes menées par tous les Etats Alpins ont montré clairement que, dès le début, l'ère industrielle a menacé d'extinction l'ensemble des Alpes à cause de la disparition progressive du caractère naturel et de l'intégrité de leur environnement.

Dans le but d'arrêter cette tendance, on a souligné la necessité d'une politique globale qui repose essentiellement sur la récupération du monde alpin et de son histoire et culture traditionnelles par le rétablissement de l'environnement dégradé, par la sauvegarde sévère des régions demeurées intactes, par la relance des activités humaines traditionelles et par l'adoption d'un nouveau type de tourisme qui n'entraîne pas une ultérieure "consommation" du territoire.

BEZIEHUNG ZWISCHEN UMWELT UND MENSCHEN IM ALPINEN BEREICH

Der Mensch hat sich ab Paläolitikum in den Alpen angesiedelt, aber sein Einfluss auf die Umwelt wurde nur im letzten Jahrhundert bemerkt, und zwar seitdem der Mensch die Abnutzung des Bergbereiches mit der intensiven Ausbeutung seiner Reichtümer begonnen hat. Die von allen Alpenländern durchgeführten Untersuchungen haben ausführlich bewiesen dass seit Anfang des Industriezeitalters die Alpenumgebung mit Aussterben bedroht wurde, nämlich weil die Natur und mit ihr die Integrität der Umwelt allmählich verschwunden ist. Um diesen Prozess zu unterbrechen, stellte sich dringend die Notwendigkeit heraus, eine Gesamtpolitik der Planung herzustellen, deren Richtlinien sich auf der Verwertung der Gebirgswelt, ihrer Geschichte und traditionellen Kultur gründen; das heisst Wiederherstellung der beschädigten Umwelt, strenger Schutz von den noch unberührten Zonen, Wiedereinführung der traditionellen Volkstätigkeiten und neue Pläne für den Fremdenverkehr, die keine weitere Gebietabnutzung vorsehen.

Potential Wildlife Problems in Canadian Forests Managed for Maximum Biomass Production

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POTENTIAL WILDLIFE PROBLEMS IN CANADIAN FORESTS MANAGED FOR MAXIMUM BIOMASS PRODUCTION

World petroleum shortages have renewed interest in wood as a raw material for energy and chemical production. Intensive management of forests to produce maximum biomass yields would change habitat for forest wildlife on a vast scale. Four forest management alternatives of increasing intensity are examined. Potentially serious impacts for forest wildlife include removal of snags needed by cavity-nesting species, reduction of area of stands of good snow-catching ability needed by wintering deer (Odocoilius spp.) and lower ecological diversity. Wildlife damage to expensive growing stock is expected to grow increasingly serious as management intensifies.

PROBLEMAS POTENCIALES DE LA FAUNA DE LOS BOSQUES CANADIENSES MANEJADOS PARA LA PRODUCCION MAXIMA DE BIOMASA

La escasez mundial de petróleo ha renovado interés en la madera como forma de materia prima para energía y producción química. La dasocracia intensa para producir el rendimiento máximo de la biomasa cambiaría el habitat de la fauna silvestre forestal en una escala inmensa. Cuatro alternativas de dasocracia para aumentar la intensidad son examinados. Impactos potenciales serios para la fauna silvestre forestal incluyen la eliminación de fustes muertos que son necesitados por algunos especies, reducción del área de la masa, con buena habilidad para detener la nieve, que el venado (Odocoileus spp.) necesita en el invierno, y la diversidad ecológica baja. Se estima que el daño de la fauna silvestre al costoso ganado será cada vez más serio con la intensificación del aprovechamiento.

PROBLEMES POSSIBLES POUR LE GIBIER DANS LES FORETS CANADIENNES ADMINISTREES POUR LA PRODUCTION MAXIMALE DE BIOMASSE

Le manque de pétrole dans le monde a renouvelé l'intérêt dans le bois comme matière première, comme source d'énergie et de produits chimiques. L'exploitation intensive des forêts pour une production maximale de biomasse changerait énormément l'habitat du gibier. Cet article examine quatre alternatives pour la gestion des forêts dans un ordre croissant d'intensité. Parmi les impacts sérieux possibles sur le gibier sont 1) l'élimination des arbres morts dont certaines espèces d'oiseaux ont besoin pour leurs nids, 2) la réduction des surfaces avec des arbres groupés capables de retenir la neige dont ont besoin daims etc. 3) moins de diversité écologique. Avec l'intensification de l'exploitation des forêts les dégâts causés par le gibier sur les jeunes arbres coûteux deviendront de plus en plus graves.

POTENTIALE NUTURWILDPROBLEME IN CANADISCHEN WALDERN, DIE FUR MAXIMALE BIOMASSENPRODUKTION BEWIRTSCHAFTET WERDEN

Der Weltpetroleummangel hat wiederum Interesse an Holz als Rohmaterial für Energie- und chemische Produktion hervorgerufen. Intensive Forstwirtschaft zur Produktion von maximaler Biomassenerzeugung würde die Umwelt für die Tiere des Waldes ausserordentlich verändern. Potentiale schwerwiegende Einflüsse auf die Waldtiere schliessen ein: die Entfernung von toten Bäumen, die von Höhen nistenden Spezies benötigt sind, Verkleinerung von Forstbeständen, die gute Schneeauffangmöglichkeiten haben und von Hirschen (Odocoileus sp.) und Tieren von geringerer ökologischer Entwicklungstufe im Winter gebraucht werden.

Australian Agro-Forestry:

Pines and Pasture for Profit, and Eucalypts for Salinity Control

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AUSTRALIAN AGROFORESTRY:
PINES FOR PASTURE AND PROFIT,
AND EUCALYPTS FOR SALINITY CONTROL

In Australia pines and eucalypts are grown, for timber production and salinity control respectively, with undersown annual pastures for livestock production. The diverse benefits seen for these agroforestry systems are discussed and relevant research is outlined.

L'AGRO-SYLVICULTURE EN AUSTRALIE: PINS ET PATURAGE POUR LE PROFIT, ET EUCALYPTUS POUR LE CONTROLE DE LA SALINITE

En Australie les plantations de pins et d'eucalyptus servent respectivement à la production de bois et au contrôle de la salinité du sol. Sur les terres de ces plantations il est semé une herbe annuelle de pâturage pour la production de bétail. Les divers avantages de ces systèmes d'agro-sylviculture sont discutés et les recherches pertinentes sont présentées dans cet article.

LA AGRI-SILVICULTURA AUSTRALIANA: PINOS Y PASTIZALES PARA GANANCIA, Y EUCALIPTOS PARA EL CONTROL DE SALINIDAD

En Australia, pinos y eucaliptos son cultivados para la producción de madera y control de salinidad, respectivamente, con pastizales anuales por debajo para la producción de ganado. Se mencionan los beneficios diversos observados de estos sistemas agro-dasonómicos, y se incluye un bosquejo de investigaciones pertinentes.

AUSTRALISCHE AGRAR-FORSTWIRTSCHAFT: KIEFERN UND WEIDEN FUR PROFIT, UND EUKALYPTUS FUR BODENSALZKONTROLLE

Kiefern und Eukalyptus, mit jährlich gesäten Weiden für Viehzeugproduktion im Unterstand, wachsen in Australien und liefern Nutzholz sowie Schutz gegen Bodenversalzung. Die verschiedenen Gewinne dieses Agrar- Forstsystems sind besprochen und richtungsgebende Forschung ist projeziert.

A Brief View of the Greenbelt in Algeria and Its Place in the Fight Against Desertification

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A BRIEF VIEW OF THE GREEN BELT IN ALGERIA, AND ITS PLACE IN THE FIGHT AGAINST DESERTIFICATION

Several years ago, Algeria initiated a green belt program to fight against desertification. It deals with the northern Sahara area, which is limited by the Piedmont of Saharian areas, and further north by high steppish plateaus and areas of high corn production. The project area covers about 3 million hectares, 1500 km long and 20 km wide. This is the area that is directly subjected to desertic influences.

The green belt area is subjected to harsh ecological conditions. It is in a mountainous zone, which receives 250 to 300 mm average annual rainfall (10 to 13 inches). Its arid and semi-arid cold climate is related to the Mediterranean accentuated climate: continentality and strong summer dryness for more than 4 months.

The primary agricultural activities include raising sheep and alfa (Stipa tenacissima). Other forms of agriculture are practiced only occasionally.

The purpose of the green belt project is to increase the total forested area by (1) improving the existing natural forest, and (2) afforestation of 1 million ha (2.5 million acres) of bare lands. Similar efforts are being made to improve and increase grasses and other human activities in the green belt area.

The first results are good. New information has been developed for a better understanding of the problems, so that the program now has better technical and scientific bases for better results.

UNA VISTA BREVE DEL "CINTURON VERDE" EN LA ALGERIA, Y SU IMPORTANCIA EN LA LUCHA CONTRA LA DESERTIFICACION

Hace varios años, Argelia inició un programa de "cinturón verde" para combatir la desertificación. Se trata del área norte del Sahara, la cual está limitada por la porción baja de las montañas de las áreas saharianas, y más al norte por el altiplano escalonado y áreas de alta producción de maíz. El área proyectada cubre casi 3 millones de ha., 1500 km. de largo y 20 km. de ancho. Esta es el área que está sujeta directamente a influencias deserticas.

El área del "cinturón verde" está sujeta a condiciones ecológicas rigurosas. Es una zona montañosa, la cual recibe 250 a 300 mm. de lluvia anual (10 a 13 pulgadas). Su clima frío, árido o semiárido está en relación al clima acentuado del mediterráneo--continental y sequedad fuerte del verano por más de 4 meses.

Las actividades agrícolas primarias incluyen crianza de ovejas y esparto (Stipa tenacissima). Otras formas de agricultura son practicadas sólo de vez en cuando.

El propósito del proyecto del "cinturon verde" es aumentar el área total arbolada con (1) mejoramiento del bosque natural existente, y (2) plantación de un bosque de 1 millón ha. (2.5 millones de acres) de tierra rasa. Se están haciendo esfuerzos similares para mejorar y aumentar los pastizales y otras actividades humanas en la zona del área del "cinturón verde."

Los primeros resultados son buenos. Nueva información se ha desarrollado para el mejor entendimiento de los problemas, y el programa ya tiene una mejor base técnica y científica para rendir mejores resultados.

UN EXAMEN RAPIDE DE LA ZONE VERTE EN ALGERIE, ET DE SA PLACE DANS LA LUTTE CONTRE LA DESERTIFICATION

Il y a quelques années, l'Algérie a commencé un programme de zone verte pour lutter contre la désertification. Ce programme porte sur la région du nord du Sahara, qui est entourée par le Piedmont des régions du Sahara, et plus au nord par de hauts plateaux ressemblant à des steppes, et par des régions à grande production de maïs. La région du programme a une superficie de trois millions d'hectares, est longue de 1500 km et large de 20 km. C'est la région qui est directement soumise aux influences désertiques.

La zone verte est soumise à des conditions écologiques rudes. Elle se trouve dans une zone montagneuse qui reçoit de 250 à 300 mm de pluie annuellement en moyenne. Son climat froid, aride et semi-aride ressemble au climat méditerranéen très marqué: continental et avec une grande sécheresse en été pendant plus de quatre mois.

Les activités agricoles principales comprennent l'élevage des moutons et de l'alfa (*Stipa tenacissima*). D'autres formes d'agriculture se pratiquent seulement occasionnellement.

Le but de la zone verte est d'accroître la superficie boisée par 1) l'amélioration de la forêt naturelle qui existe déjà, et par 2) le boisement d'un million d'hectares de terrain dépouillé. Des efforts semblables se font pour améliorer et accroître l'herbage et les activités humaines dans la zone verte.

Les premiers résultats sont bons. De nouveaux renseignements ont été obtenus pour une meilleure compréhension des problèmes, et le programme a maintenant une meilleure base technique et scientifique pour produire de meilleurs résultats.

EIN KURZER UEBERBLICH UEBER DEN GRUENGUERTEL IN ALGERIEN SOWIE UEBER DEN STAND DER BEKAEMPFUNG DER VERWUESTUNG

Algerien begann vor mehreren Jahren ein Programm zur Bekämpfung der Verwüstung. Es handelt sich um die nördliche Sahara, begrenzt durch die Sahara Piedmont Gebiete und weiter nördlich durch hochgelegene Steppengebiete sowie Gebieten hoher Getreideproduktion. Die Projektfläche umfasst ca 3 Mio. Hektaren und ist ca. 1500 km lang und 20 km breit. Dieses Gebiet untersteht direktem Wüsteneinfluss.

Der Grüngürtel ist harten ökologischen Bedingungen unterworfen. Er umfasst eine Gebirgszone mit einem mittleren jährlichen Niederschlag von 250-300 mm, dessen trockenes und halbtrockenes, kaltes Klima dem Mittelmeerklima verwandt ist: Kontinentalklima mit mehr als 4 monatiger Trockenzeit im Sommer. Die wesentlichsten landwirtschaftlichen Aktivitäten umfassen Schafzucht und Alfa (*Stipa tenacissima*). Andere Formen der Landwirtschaft sind selten.

Der Zweck des Grüngürtel Projekts besteht in der Vergrösserung der totalen Waldfläche durch 1) Verbesserung der vorhandenen natürlichen Wälder und 2) durch Aufforstung von 1 Mio. Hektaren Brachlandes. Ähnliche Anstrengungen werden im Grüngürtel unternommen um Weideflächen und anderes Kulturland zu verbessern und zu vergrössern.

Die ersten Resultate sind gut. Neue Informationen für ein besseres Verständniss der Probleme sind vorhanden, sodass das Programm einen verbesserten technischen und wissenschaftlichen Rückhalt für verbesserte Resultate hat.

Deltoides Clone of Poplar Grows Better Than Hybrids

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DELTOIDES CLONE OF POPLAR GROWS BETTER THAN HYBRIDS

A study laid out in Changa Manga irrigated plantation to compare the rate of growth of 3 poplar clones has indicated that P. deltoides cv.I-63/51 continued to perform better than hybrids cv.I-214 and cv.I-021 over a period of nine years.

EL CLONO *DELTOIDES* DEL ALAMO CRECE MEJOR QUE LOS HIBRIDOS

Un estudio formulado en una plantación bajo riego en Changa Manga para comparar el grado de crecimiento de tres /clones/ del álamo, indica que P. deltoides cv.I 63/5[1] continúa progresando mejor que los híbridos cv. I-214y cv. I-021 durante un período de nueve años.

LE CLONE "DELTOIDES" POUSSE MIEUX QUE LES HYBRIDES

Une étude entreprise dans le but de comparer le taux de croissance de trois clones de peuplier sur la plantation irriguée de Changa Manga a montré que, au cours d'une période de neuf ans, P. deltoides cv. I-63/5[1] se sont montrés supérieurs aux hybrides cv. I-214 et cv. I-021.

DELTOIDES KLON DER PAPPEL WACHST BESSER ALS HYBRIDEN

Eine Untersuchung einer bewässerten Pflanzung, in Changa Manga durchgeführt, zeigte an, dass P. deltoides cv. I-63/51 über eine Periode von neun Jahren kontinuierlich besseren Wuchs hatte, als die Hybriden cv. I-214 und cv. I-021.

Costs and Benefits of Multiple-Use in British Columbia

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COSTS AND BENEFITS OF MULTIPLE USE IN BRITISH COLUMBIA

Multiple use has been advocated for many years but seldom practiced intensively in British Columbia. Referrals to other agencies are routine, some goals have been defined, and developments have been halted pending technical analysis and Public input. Land has been classified, mapped, zoned, and reserved for agricultural or forest uses. Guidelines have been developed, some losses mitigated, and users brought together effectively. Planning has been improved by resource folios and coordinated resource management plans. Recent analyses indicate timberlands may be reduced 25% to protect environment, allow for economic accessibility, and avoid timber investment in areas sought by other users. Some useful experience in conflict resolution has been gained. Better documented case studies and well funded research are needed because conflicts may deepen following initial development and "first-pass" logging of many areas.

COSTOS Y BENEFICIOS DEL USO MULTIPLE EN COLOMBIA BRITANICA

Por mucho tiempo se ha hablado a favor del uso múltiple del recurso suelo, pero raramente se ha practicado en forma intensiva en la provincia de Colombia Británica. Referencias hacia otras agencias es rutina, algunos objetivos han sido definidos y los avances se han detenido en espera de resultados de los análisis técnicos y de la opinión pública. Las tierras fueron clasificadas, mapificadas, zonificadas y reservadas para usos agrícola o forestal. Se desarrollaron las reglas de uso, algunas pérdidas fueron subsanadas y los usuarios cooperaron efectivamente. La planificación fue mejorada a través del registro de los recursos y de los planes coordinados de manejo del recurso. Análisis recientes indican que la superficie boscosa se reducería en un 25% para proteger el medio ambiente, deduciéndose por inaccesibilidad económica y evitando las inversiones forestales en las áreas destinadas para otros usuarios. Se ganaron algunas experiencias útiles en la solución de objetivos antagónicos. Se precisa de estudios de casos mejor documentados e investigaciones bien fundamentadas, debido a que los conflictos o antagonismos podrían ahondarse luego del desarrollo inicial y de la "primera" extracción forestal de muchas áreas.

COUTS ET BENEFICES DE L'USAGE MULTIPLE EN COLOMBIE BRITANNIQUE

L'emploi multiple fût recommandé pour plusieurs années mais peu souvent intensivement pratiqué en Colombie-Britanique. Les references à d'autres agences sont routinières, quelques but fûrent definis, et des développements fûrent haltés en attendant l'analyse technique et le rendement Public. Les terres fûrent classifiées, cartographiées, réparties en zones, et réservées pour l'emploi agriculturel ou forestier. Des lignes de conduite fûrent developpées, certaines pertes allégées, les usagers effectivement rassemblés. La plannification fût améliorée par des folios de ressources et des plans coordinés d'aménagement de ressources. Des analyses récentes indiquent que des étendues boisées peuvent être réduites de 25% pour protéger l'environment, allouer pour l'accessibilité economique, et eviter des investissements forestiers dans des domaines recherchés par d'autres. De l'expérience utile dans la résolution de conflits fût gagnée. Des études de cas mieux documentées et de la recherche bien consolidée sont démandés puis que des conflits peuvent accroître suivant le développement initial et la coupe de "première étape" de plusieurs étendues.

UNKOSTEN UND GEWINNE DER VIELFALTIGEN NUTZUNGSWIRTSCHAFT IN BRITISCH-COLUMBIA

Vielfältige Nutzung wurde seit vielen Jahren in Britisch Columbia gepredigt, aber selten intensiv praktiziert. Es ist gebräuchlich, auf andere Verwaltungsbehörden zu verweisen; einige Ziele wurden entwickelt und Fortschritte als Folge von vorgehenden technischen Analysen und Offentlichen Debatten gebremst. Die Ländereien wurden klassifiziert, kartographisch erfasst, in Zonen eingeteilt, und für landwirtschaftliche und forstwirtschaftliche Nutzung beiseite gestellt. Richtlinien wurden entwickelt, der Effekt einiger Verluste gemildert und Nutzniesser wirksam zusammengebracht. Folios der Naturschätze und koordinierte Bewirtschaftungspläne verbesserten die Allgemeinplanung. Neue Analysen zeigen, dass Forstländereien um 25% verkleinert werden können, um die Umwelt zu schützen, ökonomischen Augang zu gestatten, und Forstinvestierung in Gebieten zu verhindern, die von anderen Nutzniessern gebraucht werden. Einige nützliche Erfahrungen in der Lösung von Konflikten wurden gewonnen. Benötigt sind besser dokumentierte Einzelfälle und finanziell gut fundierte wissenschaftliche Arbeiten, weil die Konflikte sich vertiefen können, der ersten Entwicklung und "ersten Phase" der Holznutzung in vielen Gebieten folgend.

The System Approach to Multiple-Use of Forest Resources

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THE SYSTEM APPROACH TO MULTIPLE-USE OF FOREST RESOURCES

Forest Resource Systems are complex whole of dynamically interacting elements which differ in their relationships resulting in multiplicity of alternatives for decision - making. So dynamics of forest-ecology and economics of the affected natural and societal systems in prevailing technological environment must be systematically analysed to choose suitable course of action. The synergistic characteristic of forestry production system in which each major function is assigned due weight-age will help in designing more effective strategy for the management purpose.

EL ANALISIS DE SISTEMAS EN EL ESTUDIO DE USO MULIPLE DE LOS RECURSOS FORESTALES

Sistemas de recursos forestales son el complejo total de elementos que interaccionan dinámicamente y que se diferencian en sus relaciones, resultando en una multiplicidad de alternativas que proveen la base para tomar decisiones. La dinámica de la ecología forestal y la economía de los ambientes tecnológicos dominantes deben ser analizados sistemáticamente para escoger un método apropiado de acción. Las características sinergísticas del sistemas de producción forestal en que a cada función principal le es asignada su importancia, ayudará en la creación de estrategias más efectivas para los propósitos de la administración.

L'USAGE MULTIPLE DES RESSOURCES FORESTIERES SELON LA METHODE SYSTEMATIQUE

Les systèmes des ressources forestières font une unité complexe d'éléments qui réagissent les uns sur les autres dynamiquement et qui diffèrent dans leurs rapports, ce qui résulte en une multiplicité d'alternatives pour celui qui doit prendre des décisions. Il faut analyser systématiquement la dynamique de l'écologie forestière et de l'économie dans l'environnement technologique ambiant pour déterminer les mesures à prendre. Le caractère synergistique de système de production forestière, dans lequel chaque fonction importante est évaluée, aidera à trouver une stratégie de gestion plus efficace.

DIE SYSTEMATISCHE ANWENDUNG VON VIELFALTIGER FORSTLICHER NUTZUNG

Die Schätze des Waldes sind ein vielfältiger Teil von untereinander dynamisch abhängigen Elementen, deren Beziehung zueinander sich ändert. Dieses führt zu einer Vielzahl von Entscheidungsmöglichkeiten. Deshalb muss die Dynamik der Forstökologie und -ökonomie der betroffenen natürlichen und gesellschaftlichen Systeme in der vorherrschenden technologischen Umwelt systematisch beurteilt werden, damit die richtige Entscheidung für Bewirtschaftung getroffen wird. Der synergistische Charakter des Forstproduktionssystems, in welchem jede Hauptfunktion altersmässig bewertet ist, hilft, eine intensivere Strategie für die Bewirtschaftung aufzustellen.

The Conference Field Tours:

A Synthesis of Observations on Multiple-Use Research and Application in Northern Arizona

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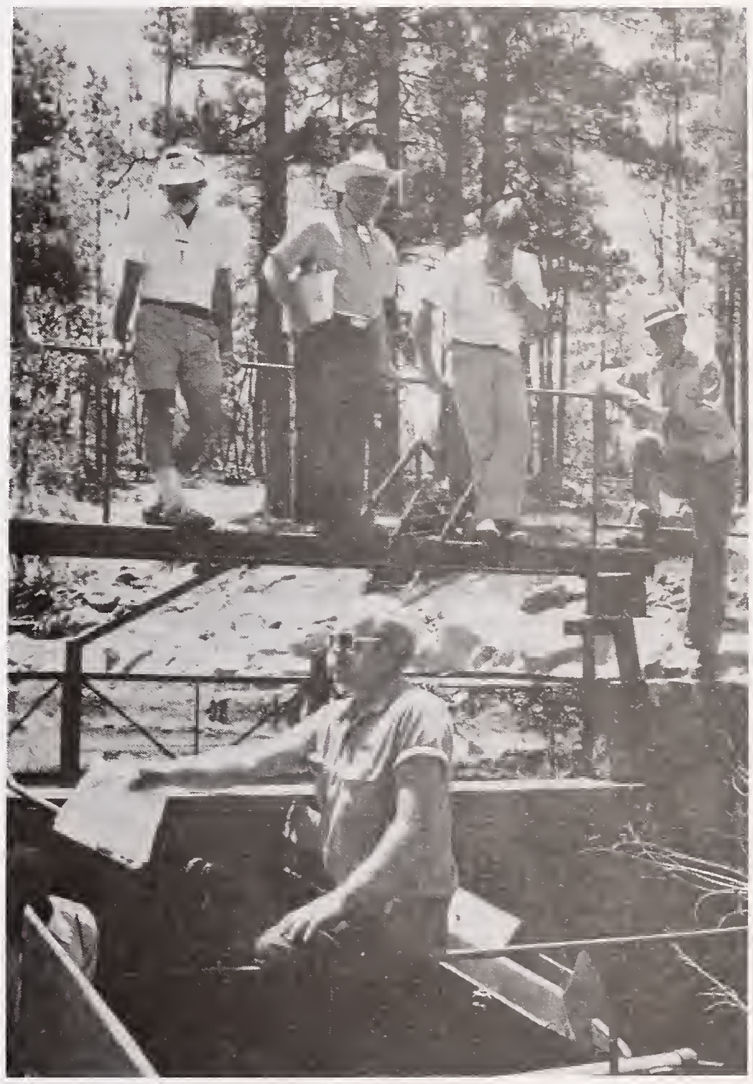
Beaver Creek Biosphere Reserve.--Watershed studies were initiated by the Southwest Region of the U.S. Forest Service in 1958, primarily as a result of concerns of downstream water users about the effects of trees and shrubs on water yields. The goal was to determine how water yields are affected by (1) conversion of pinyon-juniper types to grasslands, (2) timber harvests in ponderosa pine ranging from thinning to clearcuts, (3) wildfire, and (4) costs of benefits of all activities and resource uses tested.

In 1960, the Rocky Mountain Station joined the Region in the study, and now spends about $250,000 annually just to maintain the required measurements. The National Forest has spent $3.5 million from the Forest's budget on planned treatments. Much of the current planning and reporting is devoted to calibration and elaboration of ECOSIM, a series of ecologically based components of a comprehensive resource model. It aims at development of production coefficients tied to land management prescriptions regarding land capability and suitability for various resource uses.

Dave Garrett (Beaver Creek Project Leader) introduced the objectives of the research programs, stressing interdisciplinary aspects and relations of outputs of water, recreation, wildlife, grazing, and timber to basal area per acre. Jim Sweeney described Mormon Lake, an ephemeral lake which was full when we saw it due to the past two or three moist winters. He was proud of his success in relocation of the road to the main plateau to preserve the scenic beauty of the lakeshore. The lake supports waterfowl and occasionally fish.

On the Beaver Creek study area, Lloyd Barnett described the irregular stripcut on Watershed 14 that removed strips about 66 feet wide. Malchus Baker described the clearcutting on Watershed 12 as well as the instrumentation for measuring runoff and sedimentation, both of which were heaviest following total clearcutting about 10 years ago. Ralph Campbell described nutrient cycling, process research, and long-term research. Nutrient losses have not been substantial to date. Bill Kruse described results of treatment of Watershed 10 to increase domestic grazing and use of the area by wildlife. Cutting of clearcut patches, with or without piling of slash, resulted in improved edge habitat for elk, deer, and turkey, but results were not conclusive to date.



Malchus Baker describes the weir and sediment sampler for measuring runoff and sedimentation on Beaver Creek Watershed 12.

Clearing of pinyon-juniper "forest" by cabling or powersaw felling resulted in no significant water yield increases. Herbicide treatment did increase water yield slightly, but is no longer acceptable environmentally.

As a result of this research and environmental constraints, wide-scale clearing on public lands has been largely curtailed. Tom Brown described scenic beauty research using color slides of

standard scenes. The method has been shown to produce consistent ideas sbout relative quality of viewing among foresters, forest economists, environmental groups, and church groups. Now he is trying to identify the landscape elements that create impressions of scenic beauty.

At the Woods Canyon study area which is to be treated by the Coconino National Forest by operational practices learned in the Beaver Creek experiments, District Ranger Jim Sweeney described the development of operational plans and supporting environmental analysis. This watershed is paired with one that will serve as a control. Ralph Campbell explained how the research results will be translated into useful results for foresters from other Districts and Forests.

Two Forest staff members, Joe Prosser and Curt Johnson, are assigned to work with the researchers and help interpret their findings, operationally. For example, Johnson has assembled data on 200 models that can help in land management planning, and Prosser is working closely on operational aspects and interpretation of ECOSIM. Dave Garrett, the Project Leader, explained results to date. Testing of ECOSIM on two southwestern National Forests will begin soon.

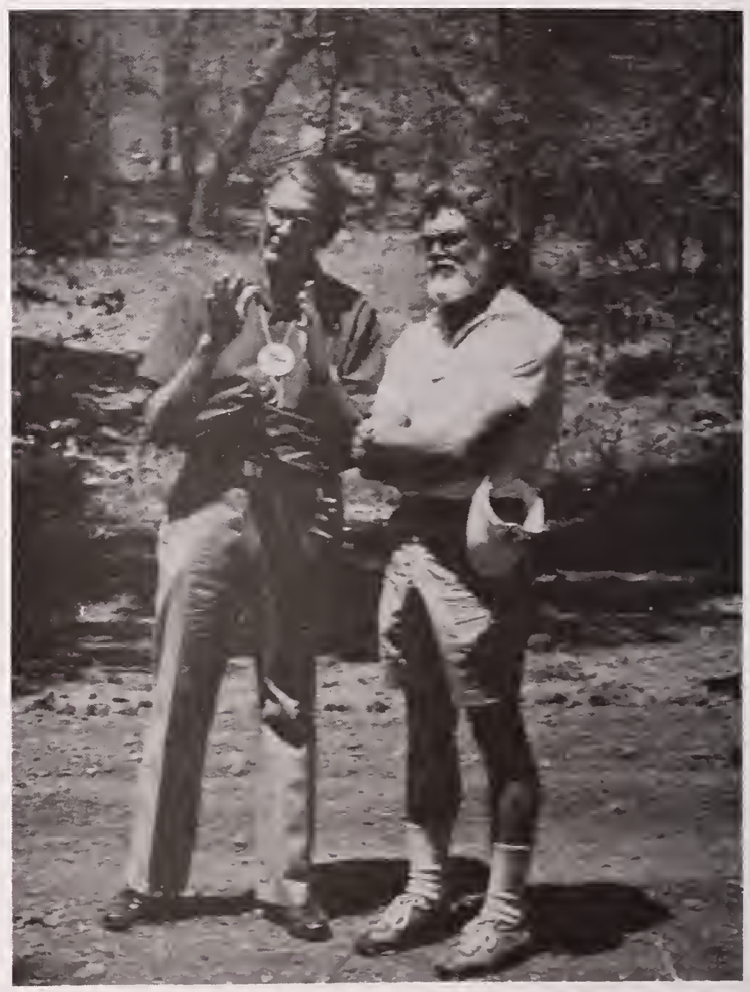
Issues that will be considered further in the Beaver Creek studies include: (1) even- versus uneven-aged management, (2) maximization of biomass growth for energy and fiber, (3) reduction of fuel loading by underburning, (4) use of tree ring analyses of widths and densities of earlywood, latewood, and ring profiles by Swedish tree ring and X-ray methods, (5) redefinition of timber management objectives as a result of reduced dbh and top diameters for sawlogs and growing markets for pulpwood, and (6) a current view of results and of costs and benefits.

Multiple Uses on the Coconino National Forest.--Forest Supervisor Mike Kerrick outlined the goods and services produced last year from the 1.8 million acres of the Coconino National Forest. There were more than 2.6 million visitors days (doubled since 1970), 370 thousand acre feet of high quality water, and 186 thousand animal unit months of grazing by domestic livestock. Forty-four ranches within the Forest graze 19,000 cattle and 6,000 sheep. Sixty-six million board feet of sawtimber, 50 thousand cords of pulpwood, 10 thousand Christmas trees, and 58 thousand cords of fuelwood are harvested annually. In 1978, 1600 of the 6200 elk on the Forest were harvested. The populations of 960 antelope, 8500 mule deer, 1610 whitetail deer, and 3000 wild turkeys also support annual harvests.

There is one Wilderness Area and two more have been designated as such under the second Roadless Area Review and Evaluation. The Forest has four Research Natural Areas, an experimental forest (Fort Valley), and the Beaver Creek Biosphere Reserve. There are 5000 miles of roads and 400 miles of trails. The fire load averages 544 lightning fires annually. Budgets were $9.6 million in 1979, $10.6 million in 1980, and $11.2 million in 1981. Currently, 700 persons are employed by the Forest.

In order to gain some perspective of the costs and benefits involved, we might ask what would the Coconino Forest be expected to provide if valued as rural real estate. Then at $200 per acre, the Forest might be worth $360 million, an amount that could be expected to yield $54 million annually at 15 percent after taxes. The water returns nothing directly to the Forest, but if it could be increased it might be worth $8.55 per thousand gallons as drinking water, $15 per acre foot for irrigation, and $50 per acre foot for domestic or industrial use.

At $2.54 per animal unit month, grazing fees would return $472,000; at $178 per thousand board feet stumpage, sawlogs would yield $11,220,000; at $1 each, Christmas trees would yield $10,000; at $3.75 per cord, firewood would produce $217,500; and 50,000 cords of pulpwood at $4.50 would bring in $225,000. Small additional values would be generated if the game animals were valued as meat. The 1,600 elk harvested might then be worth $160,000 annually. Special use permits returned $148,000 in 1979.



Warren Doolittle, Conference Chairman (left) discusses multiple-use policy on the Coconino National Forest with Jay Blowers, Executive Director of the U.S. National Committee for the Man and the Biosphere Programme, Department of State.

All of these commodity values might return roughly $12,454,500, thereby returning $2,852,000 over the amount spent on the Forest in 1979. This might be interpreted to mean that the people who use the Forest as "representatives" of other Americans actually are placing a value of about $16 a visitor day to maintain the Coconino as a National Forest.

Of course there are many additional costs and benefits, all very difficult to quantify. How does one compare the value of a skier day on the Arizona Snow Bowl on San Francisco Mountain with the value of the day of a Hopi Indian visiting there to worship at the site of his ancestor's gods? Obviously, we need sound, current results from Beaver Creek and other studies and widely agreed methods employed by managers, sociologists, and economists to determine costs and benefits and help make acceptable trade-offs among uses and user groups. The experience gained by the National Forests in applying the results of ECOSIM and FORPLAN should prove useful.

The Grand Canyon (Observations by Bal Ramdial[1]).--During my trip to the Grand Canyon, I was amazed to see the shrine that the Grand Canyon provided to meet the needs of people. Also, I was interested in learning of the special considerations given to the American Indian, i.e., the preservation of their religion and rites within National Forests and National Parks. I recall reading in the proceedings of the First World Meeting on National Parks, articles highlighting the importance of the forests to Hindu ascetics, Yogis, etc for the establishment of their ashrams. In their beliefs, many forest animals are used extensively, which has helped in conservation. In Japan, where the next World Congress will be held, there is great reverence for trees and small parcels of forests as areas quite distinct from parks and wilderness. Consequently, I wish to suggest that we recognize the spiritual function as another major role in the multiple use of forests.

[1]This statement was offered to the Conference and read by Dr. Smith on Friday. It was wholeheartedly supported by the Conference participants.

The Grand Canyon helped conference attendees view man's relationship to nature from a different perspective.

Post Conference Tour

A. Multiple-Use Management Issues on the Apache-Sitgreaves National Forest.

Nick McDonough, Apache-Sitgreaves Forest Supervisor, described 21 major issues identified by his staff that must be resolved during development of the management plan for his Forest by the spring of 1983. The issues will be taken to the public for comment, expansion, and redefinition beginning this September. The demands for all goods and services usually exceed the supply. The Forest works within broad goals assigned to southwestern forests by Renewable Resources Planning Act procedures. On every issue, there are extreme views and large grey areas of opinion between them. Major issues outlined were:

1. Operational and administrative efficiency.
2. Increased grazing opportunities for domestic livestock.
3. Increased wildlife for hunters (and reduced poaching).
4. Better roads and improved maintenance of facilities.
5. Improved public information and understanding about how to use resources.
6. Reduction of fuel loading.
7. Long-run, sustained, even-flow yields of timber.
8. Timber harvesting compatible with other uses.
9. Improved water yields and maintenance of water quality.
10. Increased utilization of timber harvesting wood residues.
11. Resolution of conflicts between free and commercial uses of residue wood as fuel.
12. Enough Christmas trees to meet the local demand.
13. Silvicultural methods to reduce other user conflicts with timber.
14. Appropriate use of Forest Service water in relation to State goals and laws.
15. Compliance of timber harvesting activities with Federal laws regarding point sources of pollution.
16. Maintenance of soil productivity, especially on steep slopes.
17. Management appropriate for wilderness, wild and scenic rivers, endangered species, and similar use categories.
18. Increased recreational opportunities in the water-rich, high-elevation conifer zones.
19. Land rights for expansion of urban and suburban uses now surrounded by the Forest.
20. Minimum environmental disturbance during extraction of major values in geothermal energy, coal, and copper on the Forest.
21. Control of off-road vehicular use to reduce soil damage and diminish conflicts with traditional uses such as backpacking.

The participants were very impressed by the nature and complexity of issues that must be resolved and by the efforts to develop enduring compromises among users.

B. Management of Chaparral

The tour leader, Leonard DeBano, gave an excellent slide-illustrated presentation outlining research needs and opportunities on about 3.5 million acres of brushlands at middle elevations. In this zone which has 16-25 inches of precipitation and storm intensities of up to 1.5 inches in 15 minutes, appropriate control of vegetation may yield 1,200 pounds per acre of forage annually, or increase water yields up to 3 inches or 750,000 acre feet per year. Chaparral is a vegetation type which, on steep slopes, can be devastated by wildlife; but may be transformed by prescribed fire, herbicides, and possibly goats, into a valuable grassland resource. Limited experiments on flatlands have demonstrated the feasibility of undercutting, chopping, and herbidical control of brush. Ephemeral streams have been transformed into perennial streams to benefit all users. Limited trials of conifers are being made to convert brushlands into timbered areas. Species being tested are Arizona cypress, Aleppo pine, and Canary Island pine. Research in similar California brushlands is complicated by homebuilding throughout much of the chaparral type.

C. McNary Container Nursery.

Maurice Williams of the Bureau of Indian Affairs described the methods used on behalf of the Fort Apache Indians to grow Engelmann spruce and ponderosa pine, plus small amount of other species. Seedlings are grown for 3 months to a year in 10 or 20 cubic inch Spencer Lemair "books" of four seedlings in greenhouses. Container growth became necessary because of uncertainty of dates suitable for planting. Planting takes place in late July or August, when heavy rains usually come. Growth of seedlings costs about 25¢ each and planting in holes made by powersaw augers costs about the same. Survival is variable from zero in some early trials to 80-90% after 4 years. Trees are planted at 400 per acre. Quality is maintained by measurement of electrical conductance of seedlings before planting.

D. Boyce-Thompson Southwestern Arboretum.

An excellent collection of native and exotic plants from desert and semidesert regions was ably interpreted to our party by the Arboretum staff.

Conference Wrap-Up

Warren T. Doolittle,[1] Chairman
IUFRO Working Party on Multiple-Use Silviculture

We had a busy session--and from my perspective, a very productive one. Each and every participant willingly shared his or her experience and expertise to address the important subject of multiple-use research. Our surroundings, accomodations, and arrangements added much to the subject at hand.

Our keynoter, Dr. Kenneth King, provided an eloquent and lucid beginning in describing the hopes and promises for multiple-use forestry throughout the world. In some of the more developed countries, affluence has led to strong demands for recreation, aesthetics, and preservation of forests; whereas in some of the developing countries, forest lands are being used to sustain the very basic necessities of life. Extremism in either case threatens the traditional forestry conservation ethic. Clearly, multiple-use forestry can provide a means to overcome these trends and thereby assure the continued productivity of one of the world's principal renewable resources. Dr. King and many others stressed that, especially in the tropics, agroforestry is coming into its own as a viable alternative to deforestation.

Our banquet speaker, Mr. Douglas Leisz, provided an excellent history and perspective of multiple use in the United States, where forests are now almost routinely looked to for a balance of uses and outputs, including water, wildlife, recreation, timber, and grazing.

Our discussions indicated that for virtually every forest function there are relevant research questions which need answering if the science and art of multiple-use forestry is to progress. Some of the more prominent research questions that emerged from the Conference are the need to learn how to increase the production of wood, how to better regulate and improve the flow of clear water, how to provide diversity for wildlife, how to better produce agricultural and forest crops from the same land, how to protect the soil and improve the productivity of the ecosystem, how to best provide for recreation and spiritual values, and how to manage for an harmonious balance that maximizes the usefulness of forests for all mankind.

We confirmed that multiple use science is active and healthy throughout the world. Our methodology, though varied, is improving. We are capitalizing on basic agronomic principles and techniques. We are using modern experimental approaches. We are becoming more quantitative and analytical. Computers are used to analyze our data. A systems approach is becoming commonplace. Yet at the same time, we are becoming more humanistic. We are beginning to understand how to evaluate and use people's perceptions as well as monetary indicators to evaluate benefits and costs. We are aiming and carrying out our programs to engage and directly help the people who depend on the land and its resources for food, wood, and other uses. Both individuals and teams cleverly using the resources at hand are making valuable contributions that are being applied to multiple-use forestry.

But we have a long way to go to fulfill our goals and aspirations for multiple-use science. For instance, we have not adequately addressed such important and key questions raised by Dr. King as: 1) the provision, possibly by IUFRO and MAB, for a published "set of first principles" for forest hydrology; 2) how to address the ". . .fundamental problem of multiple use--the compatibility [including forest damage] of forest [plant] and wildlife species" 3)the absence of "--information which would enable us to predict with any certainty the quantity of erosion that would occur if forests were exploited at various intensities. . .", or "how to manipulate our forests in order to achieve a desired quantity of timber production and to attain a desired degree of erosion control;" 4) the ". . .refining of the methodology designed to quantify the various [recreational] attitudes [of people], and the formulation of research instruments and techniques--to relate the attitudinal findings to the management of the forests;" 5) the optimal "agricultural and forestry" combinations and "basic principles" for scientific agroforestry;---6) "the methodology of quantifying forest services and relating them to multiple use" in terms of both systems and socio-economic concepts. Perhaps these and other multiple-use research problems can be addressed by our science in the coming months in preparation for the IUFRO Working Party on Multiple-Use Research which meets next with the 17th IUFRO World Congress to be held in Kyoto, Japan, September 6-17, 1981.

In our business meeting this week, three priority areas were identified for emphasis: Agroforestry (on the more basic research aspects, with focus on species combinations and protein production); production functions of multiple use (with Beaver Creek as a possible example); and definition and practice of multiple use. Wildlife habitat was chosen as a subject for joint consideration with the IUFRO Working Party on Forest Management Practices--Effects on Wildlife. These can make a fruitful forum for helping to resolve further the many questions raised during the past week.

The charge is clear, and hopefully the Conference has helped each of us become better prepared and committed to fulfill our role.

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